AN ANALYSIS OF HIGH SCHOOL STUDENTS LEARNING DIFFICULTIES IN BIOLOGY

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

HÜLYA KABLAN

ABSTRACT

AN ANALYSIS OF HIGH SCHOOL STUDENTS LEARNING DIFFICULTIES IN BIOLOGY

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This study was performed to determine what content in biology was perceived as difficult and important to learn and to investigate whether there is a relationship between reasoning ability, gender, perceived difficulty and importance. A total of 397 Grade 11 students and sixteen biology teachers participated in the study. Students and teachers' perceptions of difficult and important to learn concepts were determined through a questionnaire. Moreover, semi-structured interviews were conducted with students and teachers to determine the intrinsic difficulties and sources of difficulties. Descriptive statistics was used to determine frequencies of difficult, moderate and easy biology concepts as perceived by students and teachers. Biotechnology and genetic engineering, hormones, photosynthesis, genes, Mendelian genetics and respiration were found to be difficult concepts for students to learn. On the other hand, the students identified producers, consumers, and decomposers, active transport, diffusion and osmosis as easy topics. In addition, cell, enzyme, cell division, respiratory system in vertebrates, protein synthesis, and

reproduction in animals are selected as important topics in the curriculum to be learned. On the contrary, body systems in invertebrates and animal tissues are found to be less important topics to be learned. Students' reasoning ability was assessed by using Group test of Logical Thinking (GALT). While a statistically significant negative correlation was found between reasoning ability and percieved difficulty (r= -.115, p<. 05), no statisticaly significant relationship between gender and perceived difficulty was found.

Key words: Learning difficulties, Biology concepts, Reasoning ability, Gender

ÖZ

LİSE ÖĞRENCİLERİNİN BİYOLOJİ DERSİNDE ZORLANDIKLARI KONULARIN ANALİZİ

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Yüksek Lisans, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü
Tez Yöneticisi: Doç. Dr. Ceren Tekkaya

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Bu çalışma lise son sınıf öğrencilerinin biyoloji dersinde anlamada zorlandıkları ve önemli olarak gördükleri konuları saptamayı ve biyoloji konularını anlama zorlukları ile mantıksal düşünme yeteneği ve cinsiyet arasında bir ilişkinin olup olmadığını test etmektedir. Toplam 397 lise son sınıf öğrencisi ve 16 lise biyoloji öğretmeni bu çalışmada yer almıştır. Bu amaçla çalışmada öğretmen ve öğrencilere bir anket uygulanmışve görüşmeler yapılmıştır. Konuları zor, kolay ve orta derecede olarak sınıflandırmak için betimleyici istatistik kullanılmıştır. Biyoteknoloji ve genetic mühendisliği, hormonlar, fotosentez, gen, Mendel genetiği ve solunum öğrencilerin anlamakta zorlandığı konular olarak saptanmıştır. Buna rağmen, üretici, tüketici ve ayrıştırıcılar, aktif taşıma, difüzyon ve osmoz anlaması kolay olan konular olarak sınıflandırılmıştır. Şonuçlarda öğrencilerin hücre, enzim, hücre bölünmesi (mitoz ve mayoz), omurgalılarda solunum sistemi, protein sentezi, hayvanlarda üreme sistemi öğrencilerin önemli olarak gördüğü konular olarak bulunmuştur. Bunun yanında,

öğrenciler omurgasızlarda vücut sistemlerini biyoloji dersi için daha az önemli konular olarak belirlemiştir. Ayrıca Öğrencilerin mantıksal düşünme yeteneğini ölçmek için GALT testi uygulanmıştır. Mantıksal düşünme yeteneği ile öğrenme zorluğu arasında negatif bir korrelasyon (r= -.115, p< . 05) bulunmasına rağmen, öğrenme zorluğu ile cinsiyet arasında bir ilişki saptanmamıştır.

Anahtar Kelimeler: Öğrenme güçlüğü, Biyoloji konuları, Mantıksal düşünme yeteneği, Cinsiyet

TO MY FAMILY

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CHAPTER 1

INTRODUCTION

When students enter high school in Turkey, the first difficulty they face with is the number of different courses. Most of their elementary school courses are separated into more specific branches. One of these is the science lesson, which is broken into physics, chemistry and biology. This is in fact a good step in specializing in different sciences and understanding the diversity among science branches. Biology obviously fits best to the definition of "the science of life". Besides our own beings as a living organism, recent developments in genetics and biotechnology, the interest of the media to biological advances, developments in medicine and our overall daily life always keep our attention on biology. This is also valid for the students. Due to these points, high school students begin to like biology and feel its importance in understanding the life inside and around them.

However, biology, a wonder course, does not always come to a place it deserves. Students start to dislike it, and lose their attention after a time. Some reasons might be as follows. They realize that some courses have more importance than others. This is, of course, determined by the number of multiple choice questions asked in ÖSS (University Entrance Exam). Biology is perhaps the most unfortunate branch of science with only 12 questions out of 88 total science and mathematics questions. The amount of foreign terms, diverse topics and the pushing time limits gradually discourage students from studying biology. This gradual decline in the interest to biology lessons results in the well-known failure of achievement in biology. There are two evidences taken in order to evaluate the achievement in biology: Third International Mathematics and Science Study (TIMSS) and the results of ÖSS.

Firstly, TIMMS was the largest and most wide-ranging international study of education ever undertaken. TIMSS 1999 was designed to provide a base for understanding of educational systems of 41 countries including Turkey. It compared to mathematics and science achievement of students in these countries. It was designed to provide trends in eighth-grade mathematics and science achievement in an international context. The aim was to improve the teaching and learning of mathematics and science for students everywhere by providing data about what types of curricula, instructional practices, and school environments result in higher students achievement (TIMSS, 1999). There were six content areas in the study: earth science, life science, physics, chemistry, environmental and resource issues and lastly scientific inquiry and the nature of science. The results of TIMSS 1999 showed that achievement scores of Turkey are below the international average for biology like other science fields. TIMSS 1999 also investigated gender effect on achievement. In many countries gender difference for science achievement was negligible, so for Turkey (Ozcan, 2003). Second reference giving information about the achievement in science of Turkish students is University Entrance Examination. Table 1.2 shows the mean values of mathematics, physics, chemistry and biology lessons between 1996-2002.

Table 1.1. The mean values of mathematics, physics, chemistry and biology lesson in university entrance examinations between the years 1996-2002 (Student Selection and Placement Center, ÖSYM)

Year	Mathematics	Physics	Chemistry	Biology
1996	6.69	2.72	2.14	**1.73**
1997	13.80	5.27	6.07	**3.36**
1998	14.98	7.12	4.10	**3.93**
1999	7.73	1.65	1.25	**0.65**
2000	7.14	1.58	1.70	**1.17**
2001	7.82	2.15	1.39	**0.61**
2002	8.73	3.16	1.39	**0.99**

It can easily seen from Table 1.1. that biology averages are the lowest in science and mathematics field. Therefore the reason underlying this decrease is a valuable point to be investigated. This low level of achievement

wasinvestigated by Ozcan (2003). Her study revealed that students' difficulty in biology is one of the possible reason for low level of achievement.

Students' difficulties in learning biology concepts have been investigated by many researchers from different countries. For example, Johnstone and Mahmoud (1980) surveyed high school biology students on their perceived difficulty of isolated biology topics and reported that osmosis, water transport in plants and genetics were regarded by students and teachers as being among the most difficult concepts to learn. In a separate study, Finley, Stewart and Yarroch (1982) investigated the teachers' perceptions of important and difficult science concepts. Cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis, were found to be difficult and important topics for students to learn. Moreover, Lazarowitz and Penso (1992) identified the Israeli high school students' learning difficulties in biology concepts such as cells, organelles, organs, and physiological processes, hormonal regulation, oxygen transport, controlled experiments and the principle of structure and function. The research carried out by Bahar, Johnstone and Hansell (1999), showed that monohybrid and dihybrid crosses and linkages, genetic engineering, meiosis, central nervous system, gametes, alleles and genes were perceived by Scottish first year university students as the topics of highest difficulty. Recently the study conducted by Lewis and Wood-Robinson (2000) demonstrated students' poor understanding of the processes by which genetic information is transferred. Research on student learning also indicates that even after instruction, students have difficulties understanding topics related to flow of matter and energy in ecosystems (Eisen and Stavy, 1992; Anderson, Sheldon, and Dubay, 1990).

The studies performed in the field of education also showed that concept understanding is related to the student's cognitive developmental level (Lawson and Renner, 1975). Research has suggested significant relationship between reasoning abilities and biology achievement (Johnson and Lawson, 1998; Cavallo, 1996; Lawson and Thompson 1988; Ehindore, 1979). Johnson and Lawson (1998) investigated the relative effects of reasoning ability on biology achievement in expository and inquiry classes. They found that reasoning ability explained a significant portion of variance in

final examination score in both instructional methods. Moreover, Cavallo (1996) reported that reasoning ability best predicted students' achievement in solving genetics problems. Also, Ehindore (1979) reported that the brightness defined by students' performance on the biology tests is significantly related to the cognitive developmental precocity. Furthermore, Lawson and Thompson (1988) tested the hypothesis that formal reasoning ability is essential for seventh-grade students to successfully deal with prior misconceptions and develop scientifically acceptable biological conceptions concerning genetics and natural selection. The results showing that number of misconceptions is consistently and significantly related to the reasoning ability supported this hypothesis. What is more, Popejoy and Burney (as cited in Odom and Kelly, 2000) reported significant differences between levels of cognitive development and understanding of diffusion and osmosis in the favour of formal students (Odom and Kelly, 2000). More recently, Sungur and Tekkaya (2004) investigated the effect of gender and reasoning ability on the human circulatory system concepts achievement and attitude toward biology. The results revealed that while there was no statistically significant mean difference between boys and girls with respect to achievement and attitude toward biology, there was statistically significant mean difference between concrete and formal students with respect to achievement and attitude toward biology.

In relation to the gender difference in the learning of life sciences, some indicated no significant difference between boys and girls (Lappan, 2000; Dimitrov, 1999; Okeke and Ochuba, 1986), while others reported significant gender differences (Soyibo, 1999; Young and Fraser, 1994) For example, the study conducted by Young and Fraser (1994), revealed significant gender differences in biology achievements of 14 and 17-year-old Australian students in favor of the boys. Furthermore, Erickson and Erickson (1984) indicated gender-related differences in biology favoring of male students. However, generally, in many of such studies the differences found to be statistically significant are not markedly large.

These studies indicated that students had difficulty in biology topics and reasoning ability is one of the underlying reasons of difficulty. Also, researches are rare in Turkey about the difficult and importance concepts in

high school biology. Although there have been many studies concerning gender, reasoning ability and learning difficulties separately, no studies conducted investigating the relationship between gender, reasoning ability, difficulty and importance.

1.1. Problems of the Study:

The purpose of this study is to investigate the students' and teachers' perceptions of important and difficult biology concepts. This study also is interested in determining the relationship, if any, between gender, reasoning ability and difficulty and importance.

The main problems of this study are explained as follows:

1.1. 1. Main Problems of the study:

1. What topics in biology were difficult for Turkish students to learn?
2. What topics in biology were important for Turkish students to learn?
3. What makes these topics so difficult?
4. What makes these topics so important?
5. Is there any relationship between gender, reasoning ability and perceived difficulty and importance in biology concepts?

1.1.2. Sub Problems of the study:

Based on the main problem, the specific research questions and sub-problems are as follows:

1. Is there a significant relationship between perceived difficulty and importance for students?
2. Is there a significant relationship between perceived difficulty and importance for teachers?
3. Is there a significant relationship between reasoning ability and perceived difficulty for students?

4. Is there a significant relationship between reasoning ability and importance for students?
5. Is there a significant relationship between years of experience of teachers and perceived difficulty?
6. Is there a significant relationship between importance and years of experience of teachers?
7. Is there a significant relationship between perceived difficulty and teachers' the faculty of graduation?
8. Is there a significant relationship between importance and teachers' the faculty of graduation?
9. Is there a statistically significant mean difference between boys and girls with respect to perceived difficulty?
10. Is there a statistically significant mean difference between students attending different types of school types with respect to perceived difficulty?
11. Is there a statistically significant mean difference between boys and girls with respect to importance level of topics?
12. Is there a statistically significant mean difference between students attending different types of school types with respect to importance level of topics?
13. Is there a statistically significant interaction between gender and school type with respect to perceived difficulty?
14. Is there a statistically significant interaction between gender and school type with respect to importance level of topics?
15. Is there a statistically significant contribution of reasoning ability and importance level to perceived difficulty?

1.2. Hypotheses of the study

The main and sub problems given above were tested with the following null hypotheses.

Null Hypothesis of Sub-problem 1 ($H_0$1): There is no statistically significant relationship between students' perceived difficulty and importance for students

Null Hypothesis Sub-problem 2 ($H_0$2): There is no statistically significant relationship between perceived difficulty and importance for teachers

Null Hypothesis Sub-problem 3 ($H_0$3): There is no statistically significant relationship between reasoning ability and perceived difficulty for students

Null Hypothesis Sub-problem 4 ($H_0$4): There is no statistically significant relationship between reasoning ability and importance for students

Null Hypothesis Sub-problem 5($H_0$5): There is no statistically significant relationship between perceived difficulty and years of experience of teachers.

Null Hypothesis Sub-problem 6 ($H_0$6): There is no statistically significant relationship between importance and years of experience of teachers.

Null Hypothesis Sub-problem 7 ($H_0$7): There is no statistically significant relationship between perceived difficulty and teachers' the faculty of graduation.

Null Hypothesis Sub-problem 8 ($H_0$8): There is no statistically significant relationship between importance and teachers' the faculty of graduation.

Null Hypothesis Sub-problem 9 ($H_0$9): There is no statistically significant mean difference between boys and girls with respect to perceived difficulty

Null Hypothesis Sub-problem 10 ($H_0$10): There is no statistically significant mean difference between students attending different types of school types with respect to perceived difficulty

Null Hypothesis Sub-problem 11 ($H_0$11): There is no statistically significant mean difference between boys and girls with respect to importance level of topics

Null Hypothesis Sub-problem 12 ($H_0$12): There is no statistically significant mean difference between students attending different types of school types with respect to importance level of topics

Null Hypothesis Sub-problem 13 ($H_0$13): There is no statistically significant interaction between gender and school type with respect to perceived difficulty

Null Hypothesis Sub-problem 14 ($H_0$14): There is no statistically significant interaction between gender and school type with respect to importance level of topics

Null Hypothesis Sub-problem 15 ($H_0$15): There is no statistically significant contribution of reasoning ability and importance level to perceived difficulty

1.3. Significance of the Study

To date, many studies have been done in order to increase the biology achievement in Turkey. Most of them were related with the methods used in teaching a specific topic or the identification of misconceptions. However, in order to increase achievement, firstly it has to be revealed at which topics students have difficulty. Besides, unnecessary material in the curriculum should appear. In addition, it has to be tested whether the content is suitable to the cognitive level of students. The importance of students' cognitive stages was discussed by many researches. It was mentioned that reasoning skills such as controlling variables, proportional, probabilistic, correlation and combinational reasoning were identified on emotional abilities for success in learning science. It is stated that ability of prior knowledge and reasoning ability to be the factors that can be predict academic achievement, depending on the instructional procedure used. It is suggested that reasoning ability may limit the academic achievement of biology college students, instructed either in expository or inquiry methods.

In this study, the perceived difficulties of students in high school biology curriculum were identified. Besides, this study provides a key for identification of important topics in the content according to students and teachers. Because biology requires formal reasoning ability, cognitive level of students is measured in the study. Consequently, these findings will provide

baseline information for increasing student achievement in biology courses. The topics determined by the study as difficult and important will help construct a better curriculum. Some precautions that could be taken are changing the sequence of the topics and elimination of some details. The relationship between the reasoning ability of the students and biology content can help to guide the simplification of the content. Furthermore, teaching methods and textbooks might be improved based on the findings of the study. If these steps could be taken, interest of students to the lesson would increase and thus their achievement would improve.

CHAPTER 2

REVIEW OF LITERATURE

This study tries to find out what content in biology is perceived as difficult for high school students in Turkey. Secondly, it seeks to answer the following question: What makes these topics so difficult? Finally, it aims to identify the relationship between reasoning ability, gender and perceived difficulty.

The purpose of this chapter is to examine the studies investigating the questions given above. Although many research has been done on biology education, only few of them focused on this question in Turkey. So, the examples from worldwide researches on this topic needed to be taken into consideration. The chapter is composed of three parts. In the first part, the research about the difficult topics is given. In the second part the reasons of difficulty are studied. As a last part, the relationship between reasoning ability and perceived difficulty is explained in the lights of different studies conducted in the area of science education.

2. 1. Research Related with Learning Difficulties

Students' difficulties in learning biology concepts have been investigated by many researchers. Johnstone and Mahmoud did the fundamental research on the issue in 1980 on 167 university students, 166 high school biology students and 50 teachers in Scotland. The instruments in the study were questionnaire, examiners' reports, teachers' questionnaires, and conversations with inspectors and lecturers. In the questionnaire, a list of topics was given to both high school and university students and they were expected to evaluate the topics as easy,

average, difficult or not taught yet. From the data of high school and university students obtained from questionnaire, water transport in organisms including osmosis, water potential and water balance, energy conversions in photosynthesis, respiration, ATP and ADP, genetics and mechanism of evolution were found to be difficult topics. In addition the same questionnaire was given to biology teachers in order to list the topics in which pupils most trouble. The responses of teachers were osmosis, water potential, and control of water in organisms, chemical energy-ATP, ADP, chemistry of photosynthesis and respiration, mechanism of evolution and lastly genes. Their results revealed that all the university and high school students and teachers classified the same topics as difficult. However, teachers relatively overrated the topics of chemical energy, photosynthesis and respiration and underrated the topics of hormones and gametes. Additionally, the Examination Board's (a Examination Institution in England) reports were taken another area to determine the difficulties of Scottish student in this study. Scottish Examination Board publishes a report on each of their examinations account on the strengths and weaknesses exhibited by candidates. Reports for a number of years (1970-1978) were examined. Students had difficulty in basic plant and animal anatomy, ecosystems, genetics, water relations in organisms, enzymes, photosynthesis, respiration, energy storage and conservation and mechanism of evolution. This list bore a marked similarity to that arising from the high school and university responses. However, examiners' criticisms must be a function of question difficulty as well as of genuine weakness in student knowledge. But in all tests it was difficult to separate these two factors. Lastly authors performed a qualitative study (informal conversations) with inspectors and lecturers in order to detect the problems of high school students in biology. According to the opinions of inspectors and lecturers, students had most trouble with water relationships in organisms and energy considerations in the building and breakdown of foods.

In a separate study, Finley et al., (1982) investigated the teachers' perceptions of important and difficult science concepts in Wisconsin. In this study, the importance of identification of practical problems at the intersection of the teacher, the subject matter and the students is expressed. Questionnaire used in the study was sent to 100 teachers at each science discipline (physics, chemistry, biology and earth science). The questionnaire had importance and difficulty categories. The category "important" means that the topic should be

given to students to acquire science knowledge. The category "difficult" means that students have difficulty in learning the content. The results of the study concerning biology, chemistry, physics and earth science are given in Table 2.1

Table 2.1. Important and Difficult Topics In Science Perceived by Teachers

Biology					
Difficulty	Mean	S.D.	Importance	Mean	S.D.
1. Cellular respiration	3.90	0.76	1. Photosynthesis	4.25	0.82
2. Protein synthesis	3.88	1.23	2. Cell division	4.11	1.06
3. Cell division	3.66	0.93	3. Cell theory	4.02	0.89
Chemistry					
1.Chemical equilibrium	3.65	1.10	1. Writing chemical Formulas	4.53	0.80
2. The mole	3.53	1.12	2.Chemical equations	4.43	1.05
3.Oxidation-reduction reactions	3.50	1.25	3. The mole	4.33	1.11
Physics					
1.Circular motion and force	3.55	0.78	1.Linear displacement: Velocity and acceleration	4.26	0.85
2.Addition, subtraction and multiplication of vectors	3.42	0.96	2. Energy and energy conservation	4.22	1.07
3.Interference patterns of single and double slits	3.34	1.14	3. Newton's second law	4.09	0.87
Earth Science					
1. Plate tectonics	3.57	1.07	1.Weathering processes	4.08	0.85
2.Location and motion of stars	3.38	1.34	2.Erosional processes	3.88	0.95

The results of this study in biology were consistent with the results of Johnstone and Mahmoud's study.

In another study, Lazarowitz and Penzo (1992) identified the learning difficulties of 150 low-achieving Israeli high school students in biological concepts. In the study, achievement test and justification key were used as instruments. The achievement test included 18 multiple-choice questions in three categories. In the first category, questions were related to the principle of

structure and function of cells, organelles and organs. In the second category, questions were related to the physiological content such as hormonal regulation processes and oxygen transport. In the last category, questions described controlled laboratory experiments on organisms and dealt with different physiological processes as well as the identification of dependent and independent variables involved in the experiments. For the purpose of identifying learning difficulties, students were asked to write justifications for their choices from the possible four items given to them in each question. Students' justifications were analyzed in order to identify mistaken answers in biological knowledge required by the question and identify whether or not the answers were relevant to the problem posed. Mistaken answers can be caused by four main reasons. Firstly, the student didn't know a specific fact and therefore he or she distorted its content using wrong evidence. Secondly, the student didn't correlate a specific fact with the particular problem in the question. Therefore he or she wrote other evidence which may be correct biologically but not relevant to the particular problem in question. Next, inappropriate explanation of the usefulness or applicability of correct and relevant students' given justifications. Lastly, inappropriate explanation of wrong or irrelevant evidence written by students as a justification for their choice.

Students' answers to the questions in the first and second categories revealed that students encountered difficulties in defining one correct and relevant function of the structures presented in the questions out of many possible alternatives. Specifically, students had difficulties in defining the function of insulin and red blood cells, when they were asked to answer the question where they were required to identify a possible reason for a certain phenomenon. In the third category of achievement test, students were required to relate their answers to relevant factors that were integrated in experiments regarding organisms, processes and variables, and to explain the impact of several combined data or facts on one phenomenon that occurred in the experiment set. In analyzing student answers to questions that dealt with controlled experiments, the following points were mentioned. Firstly, students encountered difficulties in relating their answers to the relevant factors in experiments (organisms, processes, variables). It was hypothesized that this can be explained by the manner in which students referred to the information

presented in the questions. Instead of using the information found in the questions as a basis for data analysis, the information itself was explained by students using their previous knowledge. Students' answers indicated that they selected single concepts rather than associating several concepts included in the questions. For instance, while responding to questions which included concepts like amoeba, heredity and species X, students described the organism's characteristics. In questions where concepts like photosynthesis or respiration were mentioned, students wrote about the steps of process, rather than showing a grasp of the process itself. Secondly, students encountered difficulties in separating variables investigated in the experiment and in distinguishing relevant ones from irrelevant ones. Lastly, while most of the mistakes included in students' answers were found to be accurate in their biological content, they were not relevant to the problems posed in the questions. This implies that students have reasoning difficulties.

Eisen and Stavy (1992) carried out another study in order to describe the current approach to the teaching of photosynthesis in Israel and the difficulties of students in understanding the topic. They stated that students had difficulty in photosynthesis due to the following reasons:

- Students had difficulty in treating the living body as a chemical entity and in describing biological phenomena in chemical terms
- It is difficult for students to accept that human life depends on the existence of life. They usually tend to think of plants as dependent on man and this was reflected in their difficulty in understanding autotrophic feeding.
- Interdisciplinary structure of the content (physics, biology and chemistry)

As a revision study, Bahar, Johnstone and Hansell revisited in 1999 the difficulties of Scottish students in biology, which was previously determined by Johnstone and Mahmoud in 1980. The aim of this study was to revisit the topics perceived as difficult by students, and to see what changes in student perception, if any, had occurred in the intervening period. The sample was composed of 207 first year university students who were studying biology, but not necessarily planning a career in biology. Again, a list of topics was compiled

from the published syllabuses of the Scottish Examination Board at Standard Grade and at Higher Grade (university entrance level). Also, the list was amplified from the most commonly used textbooks. The total list included 36 topic headings and students were asked to indicate their view of difficulty of each by using 4-point likert scale with 1 refers to easy and 3 is difficult. They calculated the percentages of students who had studied the topic recording it as difficult. They found monohybrid crosses, dihybrid crosses and linkages, genetic engineering, genetic control of development and metabolic processes, meiosis, central nervous system, sense organs and coordination, gametes, alleles and genes as the most difficult topics. Also, diffusion and osmosis, obtaining food in animals and plants, enzymes, active transport, secretion of materials and defense mechanisms in plants had been chosen as easiest topics. The area of transport, in the past, was rated as difficult. In the light of Mahmoud's work in early 1980's (Johnstone and Mahmoud, 1980) considerable changes were made in the Scottish syllabuses that have resulted in this difficult topic becoming accessible to students. However, the general area of genetics was still causing problems and this was not just the opinion of students, but was supported by the chief biology examiners of the Scottish Examination Board in their annual reports (1992-1995). Moreover, when the same topic list, which was given to students, was given to five senior biology teachers, all with more than five years of experience, there was some indication that student and teacher views didn't correspond. The only topic on the difficulty list on which both students and teachers agreed, was monohybrid and dihybrid crosses and linkages. In this study it was decided that one-to-one interviews with a sub-sample of students might help to throw light on intrinsic difficulties and presentational difficulties in genetics topics. The results of interviews revealed that language; mathematical content, general attitudes of students, the similarity of topics and time allowance were possible reasons of difficulty in genetics. They pointed out that complex and large vocabulary cause a difficulty in genetics because students were not confident about the precise meaning of words such as 'gene', 'allele' and 'homologous'. They were confused about the distinctions between look-like and sound-like words such as homologue, homologous, homozygous, and homozygotye. Students taught that mathematical expressions caused problems and the symbols were not used consistently by teachers and textbook writers. In addition, students pointed out that they were not always or often negative, but the intrinsic interest was clouded factors of language and representation.

The similarity of the topics can cause difficulty according to the students because teaching alike concepts such as mitosis and meiosis side by side added to confusion between them. This is a well-recognized source of physiological blockage when subtly different topics are taught side by side. Both students and teachers in the study were clear that not enough time was available to tackle difficult concepts, and that what was needed was discussion and time for digestion and experimentation.

Another study about genetics was conducted by Lewis and Wood-Robinson (2000) investigated the knowledge and understanding of genetics among 482 students aged 14-16, nearing the end of compulsory education in England. Data were collected using written questions and small group discussions. Findings show a poor understanding of the processes by which genetic information is transferred and a lack of basic knowledge about the structures involved (gene, chromosome, cell). Also, results revealed that there was a confusion and uncertainty about the relationship between genes, genetic information and chromosome. For instance students considered that 'gene' to be bigger than 'chromosome'. In addition, students were less clear about location of genes. Another finding of the study was that there was widespread uncertainty as to how genetic information is transferred from cell to cell within an organism. Most of the students were unclear as to the distinction between mitotic cell division and meiotic cell division. Moreover, most students didn't understand the processes and purposes of cell division and didn't make the link between cell division and continuity of genetic information. Also, there was a lack of awareness that all cells have a common basic structure and that cells are the basic 'building blocks' which make up an organism. Few of the sample confused cell and chromosome. Students seemed to have difficulty with the contradictory terms, which are used to describe the processes of cell division in term of chromosomes and genetic information. – divide, replicate, copy, share, split, reproduce and multiply. Similarly, students had difficulty in distinguishing between processes such as cell division, fertilization. This may have been related to the confusions about terminology. Interestingly, some students didn't accept that sexual reproduction could occur in plants; the most common reason was that they couldn't identify a mechanism.

One of the recent studies was done by Stern and Roseman (2004). They stated that the transfer of matter and energy from one organism to another and between organisms and their physical setting is a fundamental concept in life science and likely to appear in any middle-school science curriculum material. Nonetheless, while topics such as photosynthesis and respiration have been taught for many years, research on students learning showed that students have difficulties on learning these ideas. They investigated middle school curriculum materials for their support of student learning ideas concerning matter and energy transformations in ecosystems. According to their findings, curriculum materials provide little support for the attainment of the key ideas chosen for the study. They concluded that these materials did not take into account students' prior knowledge, lack of representations to clarify abstract ideas and are deficient in phenomena that can be explained by the key ideas and hence can make them plausible.

Another recent study was conducted by Ugwu and Soyibo in 2004 in Jamaica. The aim of the study was to investigate if the experimental students' post-test knowledge of nutrition and plant reproduction would be improved more significantly than that of their control group counterparts based on their treatment, attitudes to science, self-esteem, gender and socioeconomic background. Treatment involved teaching the experimental students under three learning modes - pure cooperative, cooperative-competitive and individualistic whole class interpersonal competitive condition- using concept and vee mappings and the lecture method. The control groups received the same treatment but were not exposed to concept and vee mappings. The study's second objective was to determine which of these three learning modes would produce the highest post-test mean gain in the subjects' knowledge of two biology concepts. The study's sample comprised 932 eight graders (12-13-year-old). In 14 co-educational comprehensive high schools randomly selected from two Jamaican parishes. An integrated science performance test, an attitudes to science questionnaire and a self-esteem questionnaire were used to collect data. The results indicated that the experimental students (a) under the three learning modes, (b) with high, moderate, and low attitudes to science, and (c) with high, moderate, and low self-esteem, performed significantly better than their control group counterparts. The individualist whole class learning mode engendered the highest mean gain on the experimental students'

knowledge, while the cooperative-competitive learning mode generated the highest mean gain for the control group students.

In Turkey, studies investigating the student difficulties are apparently rather rare in science education literature. To date two studies have been done in this area. One of them is carried out by Tekkaya, Özkan and Sungur (2001). In their study, students recognized hormones as the most difficult topic in the curriculum. It was interesting that students fail to relate the hormones to other systems due to the perception of hormones as separate system. They also argued that it requires rote memorization. Also, genes and chromosomes were found as difficult, because they are abstract concepts and there are many confusing terms. As well, mitosis and meiosis were labeled as difficult, because of the complexity during differentiation of phases. Lastly, the nervous system was perceived as difficult, because of rote memorization. On the other hand, students rated the concept of ecology, cell and organelles as easy, because they have been taught these topics since elementary school. In addition, students have been taught teachers used different teaching strategies such as analogy and demonstration in the above topics. In this study, gender differences were also investigated and it was concluded that boys perceive biological concepts easier than girls due to socialization factors and classroom experiences leading to low self-esteem and passive dependent behavior among girls.

Öztap, Özay and Öztap (2003) investigated the difficulties biology teachers face when teaching cell division in Turkey. During this research a questionnaire composed of open-ended questions was distributed to a total of 36 secondary school biology teachers. Findings of the study indicated that biology teachers perceived cell division as one of the most difficult subject. Meiosis was particularly difficult to teach, compared to other areas of cell division. In addition to cell division, photosynthesis, genetics and living systems were found to be as difficult. Teachers in this survey thought that models, diagrams, pictures, laboratory activities, videos alongside science textbooks could be used to increase learning potential among students. They claimed that the materials, however, were rarely used in Turkish schools, because of difficulty on obtaining them.

Özcan (2003) carried out a study aimed to explore students' and teachers' perceptions with respect to biology education at high school level in order to reveal the reasons of students' low achievement in biology as indicated by the university entrance examinations between the years 1996-2002. She conducted interviews with 45 eleventh grade high school students and 45 biology teachers. As a part of the study, photosynthesis and respiration, body systems, genetics, cellular divisions and reproduction were perceived by students as difficult.

2.2. Research About Sources of Difficulty

In the previous part of this chapter, studies related with what content of biology was perceived as difficult and important were given. In this part research about sources of these difficulties is presented in detail according to criteria proposed by Johnstone (1991). He stated that the underlying reasons causing difficulty could be divided into three main categories: nature of the message (biological content), transmission system (the methods used and facilities available) and the receivers (student characteristics.)

2.2.1. The Nature of the Message (Biological Content and Curriculum)

Johnstone (1991) stated that the common type of concepts, with which children and adults are familiar, are made up of tangible instances. The concept of 'cat' is built up from seeing a lot of cats, looking for visible and other sensory attributes, which they have in common. They are recognized as a subset of the concept animal, or even mammal. If a tiger is introduced, the concept may be modified to accommodate something of a different size but with otherwise similar attributes. However, there is no immediate sensory way to get the concept of 'element' or 'compound'. These ideas are all beyond our senses and pupils have little or no experience in constructing such concepts.

Gallagher and Yager (1981) performed a study in USA about the major problems facing science education. Five groups of science educators representing faculty at graduate institutions, graduate students, teachers, supervisors and leadership conferees were surveyed concerning their perceptions of current problems in science education. A total of 144

participants provided an average of 4,7 responses. The responses were tabulated using an emergent set of categories that resulted in six major groupings, i.e. conceptual, organizational, teacher related, student related, university and societal. The category with the most problems identified was in the area of conceptual problems (confusion regarding goals, lack of leadership, lack of theoretical base, lack of professional identity).

In addition to the study of Gallagher and Yager (1981), Lawson, Alkhoury, Benford, Clark and Falconer (2000) carried out a study in USA about categorizing the biological concepts. They divided the concepts into three general categories as, descriptive, theoretical and hypothetical concepts. The first category, descriptive concepts allow us to order and describe experience. The examples of these concepts are readily observable in nature such as environmental factors, food chains, and populations. The second category, theoretical concepts are produced by postulation and test. The observable examples of these concepts cannot be seen, no matter how long one observes, such as photons, electrons, genes, combustion, biogeochemical cycles, and photosynthesis. The last category, hypothetical concepts are concepts such as subduction and evolution with exemplars that cannot in practice be observed due to limits on the normal observational time frame. Their hypothesis three kinds of scientific concepts exist was tested by constructing and administering a test on concepts introduced in college biology. As predicted, descriptive concept questions were significantly easier than hypothetical concept questions, than were theoretical concept questions. According to developmental theory, descriptive and theoretical concept construction is linked to intellectual development since the process depends in part on procedural or 'operational' knowledge structures (i.e. reasoning patterns). The construction of descriptive concepts is the easiest because meaning come from experience and theoretical concepts is the most difficult because their meanings cannot be derived from observation. This finding was supported by Johnstone (1991) and Olsher (1999) also.

Also, they investigated whether concept construction depends in part on developmental level, and students at differing developmental levels who receive instruction on all three kinds of concepts, will vary in their ability to demonstrate knowledge of those specific concepts. In others words, students

with less advanced reasoning skills demonstrate less knowledge than more-advanced students. The sample of the study was composed of 663 undergraduate students at a major southwestern university and their ages were between 17.1-54.2. The result of the study showed that students at different developmental levels were higher on the descriptive concepts than theoretical concepts.

In separate studies, Johnstone (1991) and Lazarowitz & Penso (1992) stated that students have difficulty due to the nature of biological concepts because students cannot perceive the concepts with their sensory system or apply daily life experiences. They also affirmed that biology requires the multilevel thoughts in most of the topics. For example, at the macro level plants, animals and other organisms, accessible to the senses of living organisms, lie. At the sub-micro level cells, organelles, that are not directly accessible to the senses, are present and the biochemical level includes DNA and other chemicals. Students can be stranded at one or two levels mostly. The teachers have an ability to prepare the lessons at the three levels simultaneously. However, this is not an intellectual facility shared by novices. They may start with one corner at a time and after a long time they may continue to think along one side and combine two corners. Meanwhile they cannot follow the teacher into the body of the triangle.

Besides, abstract nature of biological content prevents the visualization of the processes, which in turn creates a difficulty in understanding. (Lazarowitz and Penso, 1992; Oztap et al. 2003)

In addition to the abstract level of content, language barrier is the second source of difficulty in biological content. The science is learned through interaction. The language is the most important mean of interaction. However, students have difficulties in this area. They may understand different meanings from the words (Johnstone, 1991; Tekkaya et al., 2001; Lozano & Cardenas, 2002; Oztap et al., 2003)

Also, Cavallo (1996) stated that students have difficulty in understanding the meanings of symbols and procedures used in Punnet squares diagrams in genetics.

Due to high terminology students have difficulties in distinguishing between processes (Lewis, 2000). The research culminated in a publication Words that Matter in Science (1985) which showed that even for the first language speakers there was a large vocabulary which students either knew that they did not understand or, even worse, that they thought meant the opposite to the correct meaning. Also, anecdotal records support the notion that many students have difficulty in interpreting `what is wanted` in a question. The linguistic development may not have reached to required level.

2.2.2. Transmission system

Johnstone (1991) underlined that problems in the transmission system of knowledge is a source of difficulty in biology. It includes the characteristics of teachers, the methods used during instruction, facilities available, textbooks and experimentation.

Concerning characteristics of teachers, they may be a source of difficulty in biology because they provide a condition where the learning occurs is related to the teachers' subject matter understanding. And they should use the appropriate methods to the subjects so the maximum learning can be achieved. Bu before doing this they should know which topics are difficult to learn (Treagust, Harrison & Venville, 1998; Özcan, 2003). In addition, the teachers' knowledge about the science is an important factor (FuriÓ, 2000). Likely, pedagogical content knowledge is vital to apply predict the characteristics of students and to appropriate teaching strategies in order to form a learning environment. (Tuan, Chang & Wang, 2000)

Regarding instruction, studies revealed that the main common misconceptions develop as a result of instruction. Also, since topics are related to each other, existing misconceptions results in difficulty in understanding new topic. Baseline information on the conceptions, misconceptions, and missing conceptions that their students may bring to class (Finley et al., 1982). For this reason, methods used during instruction are important. (Tekkaya et al., 2001).

In addition, by giving facts to the students through instruction (rote-memorization), students are not provided opportunities to develop higher-order reasoning skills, and they also not provided opportunities to develop understanding of how science works. (Lawson, Alkhoury, Benford, Clark and Falconer, 2000). Bahar et al. (1999) pointed out that since topics are interrelated and similar to each other, teaching them side by side causes confusion.

Students think that rote-memorization is a way of learning biology but it causes difficulties. The problem with learning topics in isolation from each other is that new topics, which are usually based on previously learned topics, do not make sense to students. Thus students may tend to learn biological topics primarily by rote and find it difficult to understand subsequent topics. (Özcan, 2003)

A study conducted by Banet and Ayuso in 1999 revealed that the following characteristics on teaching genetics causes problems:

- No consideration of students' prior knowledge.
- Wrong sequence of topics
- No interest of students
- Unclear definitions of the basic concepts in genetics by textbooks and teachers
- Generally meiosis is not included as an introductory course in genetics. So students cannot relate meiosis and genetics.

Concerning textbooks, the study done by Tekkaya and coworkers in 2001 pointed out that textbook is a factor causing difficulty. They contain too much new and unnecessary information. Causal relations are not emphasized in the textbooks. For this reasons, some students fail to realize the links among the topic. Kearsey and Turner (1999) stated that figures in the textbooks are helpful for students for understanding but the characteristics (size, color, drawing or the real pictures) of the figures should be thought carefully since they may cause misunderstandings or misconceptions. Also pictures should be suitable to the medium ability of students.

Regarding facilities available in biology lessons, experiments are a indispensable part of the course. Without experiments science teaching cannot be taught. Rarity of laboratory activities causes rote-memorization and difficulty in understanding of biology (Oztap et al., 2003). However, the success of the experiment is also important. The success of experiments: During the experiment students may draw different conclusions than the teacher expected. Usually they get the idea related with what they see. Unless they are explained the aim and conclusion, they may get misconceptions or they may not understand the topic. (Johnstone, 1991)

Last factor in the transmission system is the time. Research revealed that current biology class hour is insufficient because of the curriculum covering many topics. Due to time limitation, courses could not be supported by discussions, laboratory sessions and tackling of the difficult topics. (Tekkaya et al., 2001; Ozcan, 2003; Bahar et al., 1999, Lewis and Wood-Robinson, 2000).

2.2.3. Student Characteristics

Johnstone (1991) underlined that characteristics of the receivers (students) is a source of difficulty in biology. It includes the attitudes of students toward biology, misconceptions and naive theories of students and reasoning ability of the students.

Concerning attitudes, Bahar et al. (1999) expressed the importance of attitudes of students toward biology. A result of the interviews done in the study put on view that students explained that their general attitude is important. If the attitude is negative, the topic seems to be difficult. This statement is supported by the interview results in the study of Ozcan (2003). Lack of interest comes after memorization factor as a second problem students having during biology learning.

Second factor about the student characteristic was the misconceptions. There are many research had been done about the misconceptions and naive theories of the students. All of them agree that misconceptions of students prevent the understanding of new information in science teaching. Eisen and

Stavy (1992) stated that students had difficulty in photosynthesis due to naive theories for example plants are fed from the soil or water is the plants' food.

Another study about the misconceptions was done by Pine, Messer and John (2001). The aim of the study is to identify children naive theories. A questionnaire was used as an instrument and the sample was composed of teachers. As a part of the study the science topics that students have difficulty with and the types of naïve ideas exhibited by the children were analyzed. Form the results; it was clearly observed that students had difficulty in living/nonliving things, classification of living things and growth. The results also showed that students also had misconceptions on these concepts. In the questionnaire teachers affirmed that children's misconceptions were not helpful in bringing about new understanding.

In addition, Lewis and Wood-Robinson (2000) stated that the limited understanding of the nature of genetic information was due to confusion, uncertainty and a lack of basic knowledge of cell, chromosome and gene.

Besides, operational stage of the students is very important for understanding biology because Biology requires formal operational stage of learning/thinking. (Lazarowitz and Penso, 1992). Also, five formal reasoning modes consisting of controlling variables, proportional, probabilistic, correlational, and combinatorial reasoning have been identified as essential abilities for success in secondary school science and mathematical courses (Bitner, 1991; Lawson, 1982; Valanides, 1996; Smith and Sims, 1992). Studies indicated that genetics require proportional, probabilistic, combinatorial reasoning skills. Also, some genetic concepts have few perceptible examples and attributes likely to be more difficult for concrete operational students to understand.

The study of Lazarowitz and Penso (1992) showed that students had reasoning difficulty. One explanation for the reasoning difficulties may be inappropriate manner in which the different levels of biological organization are taught to the secondary school students. Choosing the correct cognitive level for instruction, in terms of what follows from the logical structure of the biological organization being presented, should be modified by an analysis of the

operational level of reasoning that is necessary for the pupil to assimilate and accommodate the concepts being taught. Only if they are found to be suitable to the student population, we can assume that student will be able to use new knowledge in a more analytical manner.

Besides, the study done by Ehindero (1979) showed that reasoning ability level of students and achievement in biology are related to each other. In the study, a biology achievement test was applied to students who have high and low reasoning ability levels. The results of the study revealed that students who have high reasoning ability are more successful in biology than the others. Also this result was corrobated by Lawson (1982), Bitner (1991), and Valanides, (1996). Likewise, Cavallo (1996) stated that students' meaningful learning orientation and reasoning ability both significantly predicted scores on the test of genetics and students with higher reasoning ability were better able to solve problems related with genetics.

Smith and Sims (1992) stated that according to constructivist theory, the understanding constructed by the student is not identical to the understanding in the mind of the teacher. Students at a given level of cognitive development are incapable of understandings that require reasoning abilities achieved only at later stages of development. Otherwise, misconceptions or difficulties in understanding the concept can be caused. Lawson and Thompson (1988) pointed out that formal operational students are predicted to hold significantly fewer misconceptions than concrete operational students following instructions.

To sum up, students had difficulty in genetics, photosynthesis, cellular respiration, nervous systems, mitosis and meiosis, hormonal control and reproduction. Also photosynthesis, mitosis and meiosis, cell, cellular respirations were marked as important topics in high school biology curriculum. The sources of these difficulties were summarized in the Table 2.2 in the light or research.

Table 2.2. Summary of sources of difficulty

FACTOR	EXAMPLES
Nature of the biological content	Interdisciplinary nature Abstract nature Terminology
Transmission systems	Facilities available Methods used during instruction Time Characteristics of the teachers Textbooks Experimentation
Students' characteristics	Attitudes of students toward biology Misconceptions and naive theories of students Reasoning ability of the students

CHAPTER 3

METHOD

In the previous chapters, purpose, problems and hypotheses of the study were presented, related literature was reviewed and the significance of the study was underlined.

This chapter is composed of six parts. In the first part, population and sampling procedure, in the second part instruments of the study will be explained. The following part includes procedure and the fourth part includes methods used to analyze data. As last part assumptions and limitations of the study will be explained.

3.1. Population and Sample

All eleventh grade public, Anatolian and private high school students attending Mathematics and Science group in Turkey were identified as the target population of this study. However, it is appropriate to define an accessible population since it is not easy to come into contact with this target population. The accessible population was determined as all tenth grade regular, private and Anatolian high school students attending Mathematics and Science group in Çankaya district of Ankara. This is the population which results of the study will be generalized. A sample of 1000 students is thought to be enough to represent accessible population.

Cluster random sampling integrated with convenience sampling was used to obtain representative sample. One district of Ankara from which the sample of the study was chosen, were selected by convenience sampling method.

Schools which were thought as clusters were randomly selected from the district. The following tables (Table 3.1 and Table 3.2.) summarize the characteristics of the sample.

Table 3.1. Characteristics of Students

		Number	%
SCHOOL TYPE	Anatolian high schools	53	13
	Private schools	105	27
	Public high schools	239	60
GENDER	Male	195	49.1
	Female	202	50.9
AGE	15	1	0.3
	16	79	19.9
	17	228	57.4
	18	86	21.7
	19	3	0.8
COGNITIVE LEVEL	Concrete	77	19.5
	Transitional	206	51.8
	Formal	114	28.7
ATTITUDE TOWARDS BIOLOGY	Dislike very much	18	7
	Dislike	39	13
	Neutral	135	20
	Like	119	27
	Like very much	86	33
TOTAL		397	100

Table 3.2. Characteristics of teachers

		Number	%
SCHOOL TYPE	Anatolian high schools	2	13
	Private schools	14	87
GENDER	Male	3	19
	Female	13	81
YEARS OF EXPERIENCE	0-5 years	7	44
	6-10 years	2	13
	11-15 years	3	19
	16- 20 years	2	12
	21-25 years	1	6
	25 and more	1	6
FACULTY OF GRADUATION	Art and science faculty	6	38
	Education faculty	10	62
TOTAL		16	100

3.2. Instruments

Data collected for this study by using a questionnaire, GALT and interviews. In the following parts, the structure and rationale of the instruments are given.

3.2.1. Questionnaire

Students' and teachers' perception of difficult and important concepts was assessed by using two separate questionnaires.

Student questionnaire was composed of three parts. In the first part, personal information (gender, age, school, last year's biology grade and interest in biology) was asked. In the second part, a list of 42 major concepts present in Turkish high school biology syllabus was presented. Respondents were asked to indicate their view of difficulty and importance of concepts in high school biology curriculum. Difficulty categories were rated on a 1-5 scale with 5 being very difficult. Likely, importance categories were rated on a 1-5 scale with 5 being very important. In the third part, in attempt to clarify the possible sources of learning difficulties, students were provided with a list of statements related to possible reasons behind their difficulties in learning biology and they were asked to put tick if they agree with the statement. They were also encouraged to write other sources that they thought create difficulty and importance. Of the 900 questionnaires sent out to the 11^{th} grade high school students; 397 were returned for a response rate 44.1%.

A similar questionnaire was administered to the teachers. The first part asked personal information like gender, experience, faculty of graduation and their school. The second part was completely the same as the students' questionnaire. In third part was that the questions were based on the idea why students have difficulty in understanding biology topics.

The initial version of the questionnaire was examined by seven experienced biology teachers. They were asked to comment on the representativeness of the items and to suggest items where they felt serious content omissions existed. Teachers' suggestions were incorporated to the final

version of the questionnaire. Also, two-experienced Turkish language and literature teachers made critics about the comprehensiveness of the language of the questionnaire. In addition it was sent to one statistician to scrutinize the structure. Then, in the spring semester of 2002-2003, the questionnaire was pilot tested with a sample of 185 11th grade students. As a result final version of questionnaire was developed.

3.2.2. Group Test of Logical Thinking (GALT)

The second instrument used in the study was Group Test of Logical Thinking (GALT).

The abbreviated GALT is a 21-item multiple-choice test developed by Roadrangka, Yeany and Padilla (1982) to assess the cognitive development of students. It persents options for answers as well as the justification or reason for that answer. In this study GALT was used for investigating the effect of reasoning abilty on perceived difficulty of students. To classify the students as concrete, transitional or formal thinkers on the basis of scores following procedure was followed: scores of 0-8 were classified as concrete, 9-15 were transitional, and 16-21 were recognized as formal thinkers. Reliability of the test was found to be 0.85 by calculating internal consistency values using Cronbach's alpha.

3.2.3. Interviews

Interviewing with individuals is the most important method in qualitative research. By the way of interviewing it is possible to obtain full and detailed answers from interviewees (Tutty, Rothery and Grinnell, 1996). An advantage of the interview is that the interviewer can clarify obscure questions and ask the respondents to expand the answers particularly important or revealing. (Fraenkel and Wallen, 1996). For this reason, it was decided that one-to-one interviews with a sub-sample of students and teachers would help to throw light on the intrinsic difficulties and presentational difficulties on biology. Separate interviews were conducted with 10 high school students and 4 biology teachers. Accordingly, two interview schedules with semi-structured type were developed to obtain information. The schedules provided 'headings' under which later

analysis could be done, such as language and terminology, time allowance or content of the topics. Form these interviews, a number of pointers emerged which gives clues to underlying difficulties. A recording device was used to record the interviews and they were all transcribed verbatim and analyzed by the researcher.

3.3. Procedure

The study started with defining the research problem specifically. Next, the related literature was reviewed in detail. Previous studies were searched systematically. Moreover, some of the documents that could not be reached were requested from abroad. All of the relevant documents were organized and read carefully by the researcher.

After a detailed review of literature, the instruments were prepared. Then the selection of the schools involved in the study was done and necessary permission was taken from the Ministry of Education for the administration of the instruments.

In the spring semester of 2002-2003, the pilot study was caiired out. According to the results, the questionnaire was improved.

After taking the necessary permissions from both school principles and teachers, the researcher administered quantitative research tools (GALT and questionnaire) to the selected 397 students and 16 biology teachers in April 2004. The instruments were administered during April because students had to learn all of the biology topics in the curriculum. One class hour was given to the participants to complete the instruments. Directions and necessary explanations made clear the questions. Students were assured that any data collected from them would be held in confidence and requested to complete each measuring tools without leaving any item as well. The questionnaire was given to teachers to complete it in their free time.

Due to time restriction and impossibility of being present in each class during administration, the researcher occasionally requested teacher support. The teachers were informed about the study and about the directions that

should be done before administration. Although no specific problems were encountered during the administration, response rate was very low because some of the students were not willing to deal with instruments or they did not complete the instruments.

Interviews were done face-to-face and recorded by a tape-recorder. Also, recordings can be replayed many times. This prevents to miss any point. In addition it helps to gain time.

Student interviews were carried out in about one week. After necessary permissions were taken from the related authorities, face-to-face interviews were made with 11^{th} grade students who involved in the study voluntarily. A comfortable and silent place is provided in order to prevent any interruption. Students were informed about the study. Also they were informed about the confidentiality of the study. Explanations were done to the student in order to clarify the question if required. They were encouraged to reflect their own ideas.

Permission of the students was taken for tape recorders. All of interviewees allow the presence of tape recorder. For this reason there was no need for handwriting. Each interviewee was labeled with number instead of his/her name at the beginning of each interview. All of the cassettes were labeled with the number and the date of the interviews to give an order to the procedure.

Similarly, teacher interviews lasted for one week. Teachers were requested for the interview and interview time was arranged in their free time. Before starting interviews a silent comfortable environment was provided and any interruption was avoided. Similar to the students' interview procedure the teachers were informed about the researcher and the purpose of the study. Teachers were made sure about the confidentiality. They were asked to allow tape-recording. And the importance of recording was explained to them. If they had any points in questions, required explanations were done.

3.4. Data Analysis Procedure

For quantitative results the data obtained from GALT and questionnaires were analyzed by using both descriptive statistics and inferential statistics. The mean, median, mode and standard deviation of the variables were presented as descriptive statistics. For inferential statistics, in order to test the null hypotheses statistical techniques, analysis of variance (ANOVA) and Bivariate Correlations were calculated.

For qualitative results obtained from interviews audio taped interviews were transcribed verbatim and analyzed. For this purpose the cassettes were replayed many times to check whether any point is missed in the text. If there were lacking parts in the cassettes, only the answers including those parts were excluded. If the missing data were high for an interviewee's responses, then all of the responses of that interviewee were excluded.

After the completion of transcriptions, responses were listed with the previously assigned number. Then responses were categorized for each question according to the similarity. So categories were formed and named. By this way these categories made up the codes. Each code was carefully examined and it was investigated if there were emerge categories under each code, which become subcodes. The number of individuals giving responses in each code was recorded. After revision, the percentages were calculated and tabulated. The best way of explaining the reasons of perceived difficulty in biology was forming tables. The procedure was the same for both teachers' and students' interviews.

3.5. Assumptions of the Study

At the beginning of the study the researcher made the following assumptions:

- The administration of the instruments was under standard conditions.
- The students of the pilot study have the same characteristics with sample.
- Subjects were expected to be sincerely involved in the study.

- All students were expected to have covered all topics in high school biology curriculum.
- One lesson period was assumed to be enough for the completion of the instruments.
- Stress and anxiety of ÖSS (University Entrance Examination) were assumed to be not effective during application of the instruments.
- Learner characteristics (e.g., Socio-economic-status, demographic variables, health related factors) did not affect perceived difficulty in biology.

3.6. Limitations of the Study

The study had the following limitations:

- The study is limited to eleventh grade science and mathematics students in three school types, namely private, Anatolian and public schools.
- The instruments (GALT and questionnaire) were sent to 900 students during April. Since this time was close to the date of ÖSS student number was lower than expected because of the following reasons: Firstly, some of the students did not come to the schools. Secondly, some of the present students were not willing to participate in the study. Lastly, some of the students did not complete the instruments.
- Due to time limitations, teachers in public high schools were not willing to make interviews and questionnaires.
- Although interviewees were encouraged to express themselves freely, they might have not exposed reality.
- One lesson hour was not enough to complete instruments. Due to less time allocated for biology courses, teachers could not provided additional time for competition of questionnaire.

CHAPTER 4

RESULTS

The findings obtained in the study are presented in 3 sub-sections in this chapter. First, participants' responses to the questionnaire are shown. In the second section, the results dealing with the interviews are presented. In the third section, relationship between reasoning ability, gender and perceived difficulty are reported.

4.1. Addressing difficult and important topics

In this part, descriptive statistics for difficult topics and important topics and inferential statistics for the analysis of null hypotheses were given.

4.1.1. Descriptive statistics

Importance and difficulty level of topics in high school biology syllabus determined for students and teachers separately. Evaluation of difficulty level was done according to the 5-likert scales, in which 1 being very easy and 5 being very difficult. Similarly, importance level was calculated according to 5-likert scales, with 1 being not important at all and 5 being very important. In analyzing data, we elected to collapse very difficult and difficult into one category. The same procedure was done for importance level of topics. Then these responses were ranked and first 15 items with the highest percentages for difficulty was given in Table 4.1. below. First 15 items were chosen as difficult according to the research done by Finley and co-workers (1982). The results showed that biotechnology and genetic engineering has been recognized by 50.8% of the students as the most difficult parts of the high

school biology curriculum to learn. Another content area that is difficult for students to learn is hormones. About 43.1% of the students indicated their difficulties in learning this concept. Although topics such as photosynthesis and respiration have been taught for many years, results indicated that students still have difficulties learning these concepts. Mendelian genetics, genes, reproductive system and nervous systems are the other conceptual areas in biology, which are perceived as difficult by the students to learn.

Table 4.1. Descriptive Statistics For Difficult Topics Selected by Students

TOPICS	% difficulty
Biotechnology and genetic engineering	50.8
Hormones	43.1
Photosynthesis	39.5
Genes	39.3
Mendelian Genetics	38.3
Respiration	38.0
Reproductive System	36.1
Nervous system	35.5
Alleles	34.3
Protein synthesis	34.0
Meiosis	33.5
Circulatory System	30.7
Excretory System	30.7
Digestive System	30.0
Tissues	30.0

On the other hand, if 20% and lower percentages of difficulty of items were marked as topics having least difficulty, scientific method, the producers, consumers and decomposers, active transport, endocytosis and osmosis can be listed as topics having least difficulty according to the results of students. The percentage of students reporting that they had difficulty in learning these concepts is relatively small (about 6-13%), which was shown in Table 4.2. below. Also, students tended to see concepts of ecology and area of transport less problematic compare to other conceptual areas (see Appendix A).

Table 4.2. Descriptive Statistics For Topics of Least Difficulty Selected by students

TOPICS	% Difficulty
Classification	17.4
Enzyme	16.4
Food Pyramid	16.1
Biotic and abiotic factors in an ecosystem	13.4
Osmosis	12.6
Endocytosis	11.9
Active transport	11.6
Producers, consumers and decomposers	11.1
Scientific method	6.6

Teachers were given the same questionnaire and were asked to rate the concepts, which they thought were giving their students most trouble. As can be seen from the Table 4.3., hormones, respiration, meiosis, and photosynthesis were found to be difficult for their students to learn by over 80% of biology teacher (see Appendix C).

Table 4.3. Descriptive Statistics For Difficult Topics Selected by Teachers

TOPICS	% Difficulty
Animal hormones	93.8
Respiration	87.7
Meiosis	87.5
Photosynthesis	81.3
Nervous system in vertebrates	74.1
Plant hormones	68.8
Digestive system in vertebrates	68.8
Plant tissues	68.8
Protein synthesis	68.8
Active transport	68.8
Reproduction in animals	62.6
Animal tissues	62.6
Osmosis	62.6
Excretory system in vertebrates	62.5
Biotechnology	53.8

However, teachers rated producers, consumers and decomposers, food pyramid, biotic and abiotic factors in an ecosystem, scientific method, asexual reproduction and respiratory system as topics having least difficulty to learn. Again the criterion is the 20 or lower percentage to be classified as having least difficulty. Results also revealed that although there was some indication that their views did not correspond, teachers generally agree with their students' views. Teachers, on the other hand, relatively overrated the topics of active transport, osmosis, and enzyme and underrate the topics of material cycles, gas exchange, and asexual reproduction (Table 4.4.). For example, although over sixty percent of biology teachers have rated active transport and osmosis as difficult topic for their students to learn, slightly over ten percent of the students indicated their difficulties in learning these concepts.

Table 4.4. Descriptive Statistics For Topics of Least Difficulty Selected by Teachers

TOPICS	% Difficulty
Matter cycles	18.8
Respiratory system in vertebrates	12.6
Asexual reproduction	12.6
Scientific method	13.0
Biotic and abiotic factors in an ecosystem	6.3
Food Pyramid	6.3
Producers, consumers and decomposers	6.3

In addition to the difficulty dimension, the second category of the questionnaire was the importance level of the concepts. The results given Table 4.5. revealed that DNA, respiration, gene, photosynthesis, meiosis and chromosome were the topics selected as important by students. Although genes, photosynthesis, respiration, meiosis were classified as difficult, students saw these topics as important. Similarly, students listed scientific method, biotic and abiotic factors in an ecosystem as easy. Also, they chose these topics as less important topics. In addition, from Table 4.6. it could be concluded that students thought that body systems in invertebrates were less important topics in high school biology curriculum. Moreover, topics related with plants like plant tissues, development in plants, reproduction of flowering plants, plant hormones were chosen as less important topics by students (See Appendix B).

Table 4.5. Descriptive Statistics For Important Topics Selected by Students

TOPICS	% Importance
DNA	82.4
Respiration	80.6
Gene	77.6
Photosynthesis	77.3
Meiosis	75.3
Chromosome	75.1
Cell	74.5
Protein synthesis	74.0
Biotechnology	72.1
Mitosis	71.5
Reproduction in animals	71.3
Respiratory system in vertebrates	70.8
Transport system in vertebrates	69.0
Enzyme	68.6
Excretory system in vertebrates	67.8
Animal hormones	65.7
Skeletal system	65.2
Development in animals	64.3
Nervous system in vertebrates	63.7
Allele	63.5
Digestive system in vertebrates	61.0
Mendelian genetics	60.9
Matter cycles	56.7
Osmosis	56.5
Classification	51.7
Active transport	53.1
Animal tissues	52.2
Food Pyramid	50.1

Table 4.6. Descriptive Statistics For Topics of Least Importance selected by Students

TOPICS	% Importance
Plant tissues	46.6
Respiratory system in invertebrates	45.6
Development in plants	45.4
Transport system in invertebrates	43.9
Nervous system in invertebrates	43.8
Reproduction of flowering plants	43.1
Endocytosis	42.4
Plant hormones	40.8
Biotic and abiotic factors in an ecosystem	39.3
Digestive system in invertebrates	38.8
Excretory system in invertebrates	38.3
Scientific method	33.5

Similar results were obtained from the questionnaire of the teachers (see Appendix D). The results in Table 4.8 showed that teachers also recorded the body systems in invertebrates and topics related with plants as topics having least importance in the curriculum. However, teachers underrated the level of importance than that of students. On the other hand, Table 4.7. in demonstrated that all of the teachers rated cell, enzyme, respiratory system, protein synthesis, reproductive system, excretory system, DNA, gene, chromosome, nervous system, producers, consumers, decomposers and transport system as the most important topics although these topics were classified as difficult for students. The relationship between difficulty and importance will be explained in the results of null hypotheses.

Table 4.7. Descriptive Statistics For Important Topics selected by Teachers

TOPICS	% Importance
Cell	100
Enzyme	100
Respiratory system in vertebrates	100
Protein synthesis	100
Reproduction in animals	100
Excretory system in vertebrates	100
Transport system in vertebrates	100
DNA	100
Gene	100
Chromosome	100
Nervous system	100
Producers, consumers and decomposers	100
Meiosis	93.8
Mitosis	93.8
Osmosis	93.8
Photosynthesis	93.8
Food Pyramid	93.8
Active transport	93.8
Development in animals	93.8
Allele	93.8
Mendelian genetics	87.6
Respiration	87.5
Endocytosis	87.5
Matter cycles	87.5
Skeletal system	81.3
Digestive system in vertebrates	81.3
Scientific method	75.1
Biotechnology	75.1
Animal hormones	75.0
Biotic and abiotic factors in an ecosystem	65.1
Asexual reproduction	62.6
Classification	56.3
Plant hormones	56.3
Reproduction of flowering plants	56.3

Table 4.8. Descriptive Statistics For Topics of Least Importance selected by Teachers

TOPICS	% Importance
Development in plants	43.8
Plant tissues	31.3
Excretory system in invertebrates	25.1
Digestive system in invertebrates	25.1
Transport system in invertebrates	25.0
Respiratory system in invertebrates	25.0
Animal tissues	25.0

4.1.2. Inferential Statistics

This section deals with the analysis of null hypotheses.

Null Hypothesis of Sub-problem 1 ($H_0$1): There is no statistically significant relationship between students' perceived difficulty and importance for students.

Pearson- Product Moment correlations were conducted to determine whether there was a relationship between perceived difficulty and importance. The results showed a statistically significant negative correlation between perceived difficulty and importance for students. (r= -.147, p= 0.03). It means that when difficulty level of a topic increases, importance level of the topic decreases.

Null Hypothesis Sub-problem 2 ($H_0$2): There is no statistically significant relationship between teachers' perceived difficulty and importance.

The results of Pearson-Product Moment correlations indicated no relation between perceived difficulty and importance for teachers (r= -.208, p=0.439).

Null Hypothesis Sub-problem 3 ($H_0$3): There is no statistically significant relationship between reasoning ability and perceived difficulty for students.

Pearson-Product Moment correlations were revealed a statistically significant negative correlation between students' perceived difficulty and reasoning ability (r=- . 119, p=. 018). In other words, students having low reasoning ability perceive the topics in biology as difficult.

Null Hypothesis Sub-problem 4 ($H_0$4): There is no statistically significant relationship between reasoning ability and importance for students.

The results of Pearson-product correlation demonstrated that there was no statistically significant relationship between reasoning ability and importance (r= . 30, p=. 554). It would appeared that cognitive development has no influence on importance level of topics

Null Hypothesis Sub-problem 5 ($H_0$5): There is no statistically significant relationship between perceived difficulty and years of experience of teachers

The results of Pearson-product correlation demonstrated that there was no statistically significant relationship between perceived difficulty and years of experience of teachers (r= -. 113, p=. 677). It means that there is no relationship between the experience and perceived difficulty.

Null Hypothesis Sub-problem 6 ($H_0$6): There is no statistically significant relationship between importance and years of experience of teachers.

The results of Pearson-product correlation revealed that there was a positive relationship between importance and years of experience of teachers (r= . 618, p=. 011). It means that more experienced teachers know the important topics in the biology more effectively. About 38.4 % of variation in importance level was explained by the teachers' years of experience.

Null Hypothesis Sub-problem 7 ($H_0$7): There is no statistically significant relationship between perceived difficulty and teachers' faculty of graduation.

The results of Pearson correlation showed there was no statistically significant relationship between perceived difficulty and faculty of graduation of teachers (r=.244, p=. 363). It means that the teachers' view about the difficulties of students does not depend on the faculty that they graduated.

Null Hypothesis Sub-problem 8 ($H_0$8): There is no statistically significant relationship between importance and teachers' faculty of graduation.

The results of Pearson correlation revealed there was no statistically significant relationship between importance and faculty of graduation of teachers (r= - .173, p=. 522). It means that the teachers' view about the importance level of topics does not depend on whether the teachers graduated from education faculty or art and science faculty.

Null Hypothesis Sub-problem 9 ($H_0$9): There is no statistically significant mean difference between boys and girls with respect to perceived difficulty

A two-way analysis of variance (ANOVA) was conducted to examine possible differences in students' perception of difficulty relative to gender. The results of two-way ANOVA indicated that there is no statistically significant mean difference between boys and girls with respect to perceived difficulty (Table 4.9.).

Null Hypothesis Sub-problem 10 ($H_0$10): There is no statistically significant mean difference between students attending different types of school types with respect to perceived difficulty.

A two-way analysis of variance (ANOVA) was conducted to examine possible differences in students' perception of difficulty relative to school type. The results of two-way ANOVA indicated that there is no statistically significant mean difference between students attending different types of school types with respect to perceived difficulty (Table 4.9.).

Table 4.9. Two-way analysis of variance about the effect of gender and school type on perceived difficulty

Source	Sum of square	df	Mean square	F	Significance
Gender	2337,941	1	2337,941	2,613	0.107
School	686,800	2	343,400	0,384	0.682
Gender x school	1520,787	2	760,393	0,850	0.428
Error	349900,760	391	894,887		

Null Hypothesis Sub-problem 11 ($H_0$11): There is no statistically significant mean difference between boys and girls with respect to importance level of topics.

A two-way analysis of variance (ANOVA) was conducted to examine possible differences in students' perception of importance level of topics relative to gender. The results indicated gender no statistically significant effect on importance (Table 4.10.).

Null Hypothesis Sub-problem 12 ($H_0$12): There is no statistically significant mean difference between students attending different types of school types with respect to importance level of topics

A two-way analysis of variance (ANOVA) was conducted to examine possible differences in students' perception of importance level of topics relative to school type. The results showed school type no statistically significant effect on importance (Table 4.10.).

Table 4.10. Two-way analysis of variance about the effect of gender and school type on importance

Source	Sum of square	df	Mean square	F	Significance
Gender	478,827	1	478,827	0,385	0,535
School	2868,884	2	1434,442	1,153	0,317
Gender x school	11806,432	2	5903,216	4,745	0,009
Error	485199,253	390	1244,101		

Null Hypothesis Sub-problem 13 ($H_0$13): There is no statistically significant interaction between gender and school type with respect to perceived difficulty.

A two-way analysis of variance (ANOVA) was conducted to examine possible interaction between gender and school type with respect to perceived difficulty. The results revelaed that there is no statistically significant interaction between gender and school type with respect to perceived difficulty (Table 4.9.).

Null Hypothesis Sub-problem 14 ($H_0$14): There is no statistically significant interaction between gender and school type with respect to importance level of topics

A two-way analysis of variance (ANOVA) was conducted to examine possible interaction between gender and school type with respect to importance level of topics. The results indicated that there is significant interaction between gender and school type with respect to importance level of topics. This interaction was presented in figure 4.1.

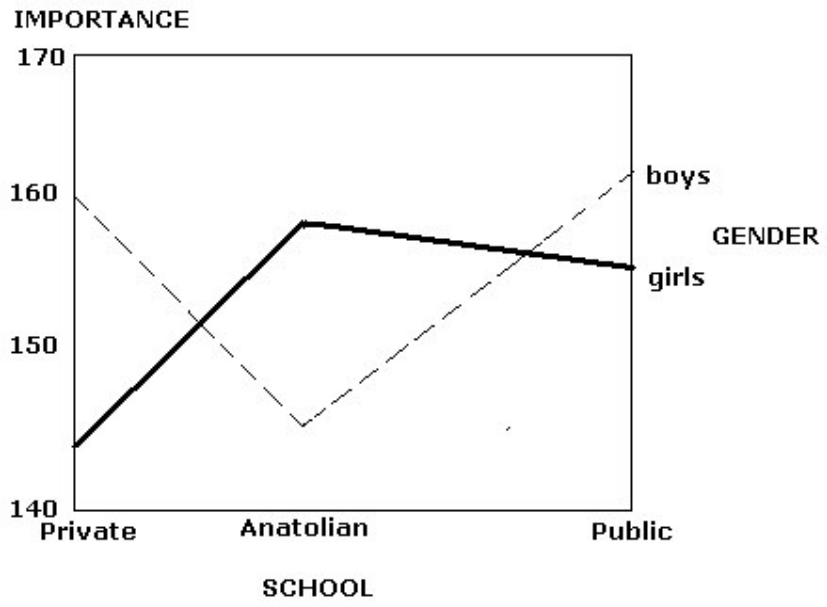

Figure 4.1. Graphic representation of interaction groups

The results shown in figure 4.1. indicated that in private schools male students see biology topics more important than female students. In public high schools the results are similar to private schools, but the difference between male and female students was smaller. However, in Anatolian high schools the situation is reverse. Female students see biology topics as more important than male students.

Null Hypothesis Sub-problem 15 ($H_0$15): There is no statistically significant contribution of reasoning ability and importance level to perceived difficulty

The contributions of reasoning ability and importance level to students' perceived difficulty level was determined by using Multiple Regression Correlation (MRC) Analyses (Table 4.11.) In this table, beta values are standardized regression coefficients, and B values represent unstandardized regression coefficients. Results showed that the model significantly accounted for 4% of the variation in the perceived difficulty (F=7.242; p<. 05). Also,

reasoning ability and importance level each made a statistically significant contribution to the variation in students' perceived difficulty.

Table 4.11. Independent Contribution of Importance Level and Reasoning Ability to Students' Perceived Difficulty

Independent variables	B	β	t	P
Constant	143.931		18.112	0.00
Reasoning ability	-0.798	-0.118	-2.380	0.0018*
Importance level	-0.129	-0.151	-3.039	0.003*

* significant at p=0.05

4.2. Sources of Difficulties in Learning Biology

After identifying the difficult and important topics, the next step in the study was to identify the possible sources of difficulty. The information for this purpose was obtained from questionnaire and interviews conducted by both students and teachers.

4.2.1. The Results of the Questionnaire

The third part of the questionnaire provides information about the possible source of difficulty. This part was composed of four questions. In the first question possible sources of difficulties were given in Table 4.12. The results revealed that majority of students (84.1 %) and teachers (87.5 %) thought that the reason of difficulty was rote-memorization. In other words, topics are difficult because students have to memorize the topics. According to the teachers the most important problem in biology was the abstract nature of concepts (93.8%). Students have difficulty because they cannot visualize the topics in their minds. Both students (38.0 %) and teacher (81.3%) thought that foreign terminology was another important problem in the biology. Lack of experiments, lack of relationship with daily life, lack of enough time and relatedness among concept were other factors causing difficulty in biology.

Table 4.12. Possible sources of difficulties (%)

Source	Student	Teacher
Depend on memorization	84.1	87.5
Lack of experiments	34.5	25.0
Presence of foreign terminology	38.0	81.3
Abstract nature of concepts	33.2	93.8
Lack of relationship with daily life	21.7	25.0
Lack of enough time	16.7	43.8
Relatedness among concept	12.3	31.3

The second question asked the reason why the respondents choose the topics as important. The distribution of the responses was given in Table 4.13. Most of the students (31.8 %) thought that DNA, respiration, gene, photosynthesis, meiosis and chromosome were important because they were asked in ÖSS and exams in school. Other possible reasons indicated by students were relatedness with daily life, human body, natural processes. Also, they were the fundamental concepts for the whole curriculum. In addition, positive attitude towards these concepts was another popular answer of students to this question. Also, another reason was that these topics provide baseline information for the development in technology. 1.7 % of students thought that these concepts were important because they are complicated.

Table 4.13. Students' explanations for importance of topics

Sources of Importance	%
They are asked in ÖSS or the exams in school	31.8
Answers the questions related with daily life	18.9
Related to the human body	15.5
Basic concepts for biology and general culture	12.5
I am interested in these topics	4.7
It provides developments in the future	9.1
Related with the processes in the nature	3.4
Related with the department I would like to go	2.4
They are more complicated	1.7

Teachers gave the same answers indicated in Table 4.14, also. However, the most frequent (37%) answer in teachers' responses was fundamental concepts for biology.

Table 4.14. Teachers' explanations for importance of topics

Sources of Importance	%
Basic concepts for biology	37
They are asked in ÖSS or the exams in school	25
Related to the human body	18
Answers the questions related with daily life	12
To understand the relationship between science and technology	4.7

The third question gave two choices to understand whether the topics related with animals or plants are difficult. Most of the students (66.0 %) and teachers (81.3 %) rated generally topics related with plants as difficult then topics related with animals as shown in figure 4.2.

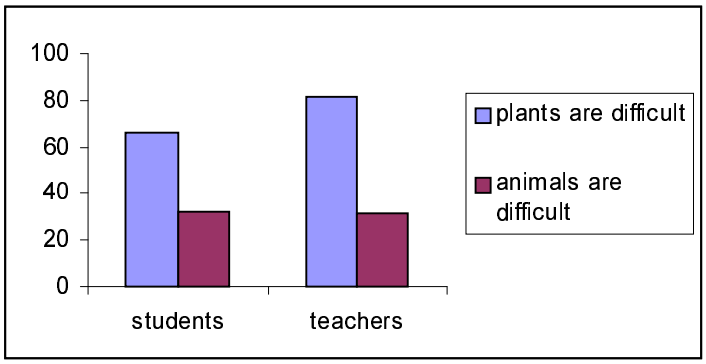

Figure 4.2. Percentages of students' and teachers' view of difficulty concerning plant and animal related topics

Students and teachers listed the possible sources of difficulty related with plants as shown in Table 4.15. Students, who listed the topics related

with animals as difficult, underlined the possible sources of difficulties in Table 4.16. However, teachers did not express any source of difficulty.

Table 4.15. Possible sources of difficulties to topics related with plants expressed by students and Teachers

Sources of Difficulty	%
Students' Responses	
Less similar to human body than animals	23
Lack of interest in plants	26
More abstract than animals	17
More confusing than animal structure	14
More rote-memorization	7
More terminology to be learnt	4
Less related with the daily life	4
More difficult to carry out experiments	4
No visualization	1
Teachers' Responses	
More abstract	50
It is less related with the daily life	31
They are not interested in plants	25
More terminology	6
It requires rote-memorization	6
It is more difficult to carry out experiments	6

Table 4.16. Possible sources of difficulties to topics related with animals expressed by students

Sources of Difficulty	%
Has more complex than plant structure	22
Has more terminology	22
Requires rote-memorization	22
Requires comprehension	11
Less number of questions asked in OSS	11

The last question was a kind of open-ended question asked in order to express other topics that were not indicated in the questionnaire perceived as difficult. However, in the answers they did not indicate any topic. Instead, they explored their ideas about the biology. Students wrote the following answers.

I think biology lessons should be related with the daily life more and students should be more active in the lessons. The course dealing with living things should not be thought so abstractly. Another difficulty in biology is the numerous topics and the teachers are obligate to complete the curriculum. (Female [F], 17 years old [y.o.], Anatolian high school [A])

I cannot visualize the structure of chromosome and genes. They seems more abstract to me. If can visualize them, I would understand the genetics. (F, 16 y.o., private school [P])

Biology is not a difficult course. Actually, it likes more to the social science courses. It requires more repetition and reasoning ability. (M, 16 y.o., P)

It is meaningless to study the transport system in invertebrates. (M, 16 y.o., P)

I cannot visualize photosynthesis. (F, 16 y.o., P)

I have difficulty in biology because topics are interrelated and I forgot the previous topics. (M, 17 y.o., P)

Biology is difficult to me because long, difficult questions dependent on comprehension are asked in OSS. (F, 17 y.o., P)

I think the course hours should be increased in biology. It is as important as the mathematics or physics courses. Actually, they are more abstract than biology dealing with life. (F, 16 y.o., P)

> More experiment should be performed. I think it is meaningless to know so much terms and many details. (F, 17 y.o., P)

> It is difficult and meaningless to learn the invertebrates and microscopic living things. (F, 17 y.o., P)

To sum up, students see topics as abstract and requires rote-memorization. Also, since topics are interrelated, it is difficult. In addition, time is not enough in order to complete heavy curriculum and to make experiments. Another point expressed is body systems in invertebrates are not important to learn.

In the questionnaire of the teachers, it was asked that whether teachers had difficulty in teaching any topics or not. However, teachers responded they had no difficulty in teaching any topics and wrote the following answers.

> Students are not interested in plant tissues. (Male [M], 1 year of experience [y.o.e], private school [P])

> Tissues require more rote-memorization and abstract. (Female [F], 10 y.o.e, P), (F, 19 y.o.e, P), (M, 5 y.o.e, P), (F, 13 y.o.e, P), (F, 5 y.o.e, P),

> Students are not interested in biology. (F, 28 y.o.e, P),

> Students have problems in understanding of mitosis and meiosis. Generally they are dealing with the details of phases. Thus they cannot see the whole picture and general purpose of the division. Specifically in meiosis they cannot understand that variation does not depend only on crossing-over. In addition, students have difficulty in osmotic pressure. I think, this is due to terminology. They think that pressure is the force exerted from inside

> to outside. However, osmotic pressure is the pressure exerted by water towards inside of the cell. Thirdly, students have difficulty in understanding of autonomic and somatic nervous system. This might be because of usage of the word 'system' every time. They think that these are different nervous systems instead of parts of the central nervous system. In my opinion, we need to decrease the amount of terminology. (F, 9 y.o.e, P)
>
> Students have difficulty in plant tissues, endocrine system and classification. These topics needs background knowledge. Also, experiments are rarely performed for these topics. (M, 3 y.o.e, P)
>
> Students have difficulty in comprehending abstract topics like evolution and starling hypotheses. (F, 24 y.o.e, P)
>
> Students have problems in meiosis, because they cannot imagine homologous chromosomes and movement of them. Secondly, aerobic respiration and photosynthesis are difficult for them, because there are so many compounds and steps of reactions to remember. Lastly, reproduction and hormones need rote memorization and have complicated terminology. For this reason most of the students cannot understand these topics properly. (F, 13 y.o.e, Anatolian High School)

To sum up, teachers expressed the students' difficulties in abstract concepts like cell division, photosynthesis, and evolution. The sources of difficulties in these concepts were lack of interest, abstract nature of the concepts, rarity of experiments and terminology.

4.2.2. Interviews

A semi structured interview protocol was constructed to detect perceptions, experiences and problem faced by students and teachers when learning and teaching biology. These aspects of the study had the potential to provide insights into the effectiveness of the biology education in Turkey. Interviews were typically of 25-30 minutes duration and undertaken at the end of the study. Given the exploratory nature of this study this data set, while limited, had the potential to inform a lager and more comprehensive project (currently underway). All interviews were audio-taped and transcribed. After reading the transcripts, a number of categories were developed. Some of these categories related directly to individual interview questions while others emerged from other aspects of the data. In discussing the research findings, excerpts from the interview data have been extracted from the appropriate categories and used to support the assertions of the researcher. All the excerpts quoted are verbatim transcriptions from the taped interviews (Pitman & Maxwell, 1992). Transcriptions have undergone light editing to improve readability (e.g., removal of repeated words, removal of filler words and changes of tense, etc.). Particular care was taken to avoid changing the meaning of any of the participants' views. Pseudonyms have been used throughout.

The first part deals with the results of interviews obtained from teachers. The second part gives information about the results of interviews carried out with 11^{th} grade students. To maintain confidence, students' and teachers' views used are referenced according to their assigned number within the parenthesis. Also, interviewee's characteristics are given.

4.2.2.1. Students Interview Results

Semi-structured individual interviews were conducted with 9 eleventh grade students.

Students' responses to the question: "At which topics did you have difficulty and why?"

Plant structure, human endocrine system and systems in human. In endocrine system, there are many confusing hormone names and I have difficulty in memorizing of hormone and their function. All the parts in plants are difficult. Plant tissues, parts of flowers, water transport in plants are difficult. Systems are difficult because they are interrelated; you have to know all of them. For example, endocrine system and digestive system are related to each other. You have to know name of hormone, its effect on digestive system, and events that occur in digestive system. (Female [F], private high school [P])

The topics that requires rote-memory such as tissues, photosynthesis, aerobic and anaerobic respiration. Steps of ETS (electron transport system) and glycolysis of aerobic and anaerobic respiration are difficult. Because there are many chemicals and chemical reactions. It is hard to remember all of them. For tissues, I cannot imagine them. They are in our body and we cannot see them. Also, there are many medical terms. ([M], [P])

Generally topics are not hard for me. It is a course that I like. But, for example endocrine system was hard to study, because of the many terms to learn. But, I have made it easy with the help of my father, who is a doctor. He told me the mechanisms of the hormones by giving examples from his hospital life. For example, what they did to a pregnant woman with Oxytocin. I think I will never forget this example. ([M], [P])

I also think that biology is not very hard, but the hardest and most dependent on memorizing topic is taxonomy. This is because it is based on the knowledge in the book,

> rather than logic. There is certainly logic in taxonomy, but expecting the student to solve it is wrong. Thus, taxonomy shouldn't be considered as very important and taught at elementary level. I think like that. . ([F], [P])

The second question asked to students was "Generally what are the sources of difficulties in biology?" Students gave the following answers:

> In biology, the most difficult thing for me is that everything is named, naturally. Those names are sometimes very similar to each other, even rhyming. Oh, there are rhyming terms like sympathetic and parasympathetic. Names like these, which seem similar, but are actually different. I have difficulty in these kinds of things. ([F], [P])

> Topics in biology need rote-memory. (Female [F], private high school [P])

> There is too much terminology you need to learn and you must use those terms to understand each other. But, all through our life we might not use all the terms we learn. For example, in excretory system there are many things we are taught and most of them are in Latin, or even if not Latin they have a specific name. I think that in our whole biology curriculum, it should be considered to give the logic of the system. For example, instead of giving the name of all the proteins or different enzymes, we could be taught that there is a certain enzyme in the stomach that does the work. I think we don't need to learn terms, which only people who will continue their life with biology need to learn. We know that biology is a lesson for learning the human body, or also other organisms. But, it is illogical to study all parts of living things. Knowing the mechanism, but not the names of the parts, will be enough for us to get the broad view. Anyway, this is our aim. ([M], [P])

> Some of the topics are not visual. They are microscopic. For example, in organic compounds carbon atom is just a letter "C". In addition, I don't have previous knowledge. They are the first things in biology for me. I forgot the knowledge that I learned in primary school. They are temporary. Biology is not an individual course at primary course. It is given with physics and chemistry. For this reason I cannot form a connection throughout the biology courses. ([M], [P])

> The topics are abstract. After you learn all the hormones and know that one works with the other as an antagonist, then learning fits as a system. But after a while you forget it, since it was just memorized. But, if you practice it you learn it for real. ([M], [P])

> There are too much detail in some topics. For example in taxonomy, it is not needed to be dwelled on so much. It is needed to mention topics like homologous and analogous organs, general logic of taxonomy. But, teaching the taxonomic places and properties of many different organisms is unnecessary. ([F], [P])

After identification of the problems the question asked was "What can be done to solve these problem?"

> Yes, it could be logical to restate with the terms. For example bio=life logy=science. By this way, the terms will be learned easily. There are some terms that are unusual, those shouldn't be taught, but teaching terms, which are necessary is important ([M], [P])

> We should not to use all of the terms. We could say easily for the enzymes in the stomach, enzymes if stomach; for the

enzymes in the mouth, we could say salivary enzymes. Things, comprehensible like this and not based on memorizing would be better. ([M], [P])

They should not be taught in details. For example, steps of glycolysis in photosynthesis should not be taught. ([M], [P])

Emphasis should be given on visual things. Like, presentations, transparencies. Because biology is more based on knowledge and visual memory is also needed. Not by only learning the terms, but also giving examples, performing the experiments, students making presentations, so that when everyone works together, it becomes more lasting. If it is not visual you study one night before the exam and scrape the information into your mind. But, you don't know exactly why it is like that. You just learn what you read from the paper. But, once you learn it with visual aids, experiment it and so on, you learn really, what the reason there is, and how it is related. And you learn something really. ([M], [P])

In other topics, rather than just giving the information on the paper, it should be connected with real life in order to make it permanent in student's mind. For example, videos, transparencies are more effective to have the student learn it. Topics that students don't know and which they can't or won't see are very strange for them. For example, the cell; you never saw it before. But, if you experiment it under a microscope, it becomes easier. ([F], [P])

Names should be more explanatory. Perhaps, it could be more Turkish names. I mean the pronunciation of terms should not be directly transferred to Turkish. For example, succession shouldn't be "süksesyon". ([F], [P])

The last question was "What are the topics which are easy to learn? Why?" The responses of the students are:

> Ecology. Because I can see the examples from daily life. ([F], [P])

> Cell is easy because we have seen this topic since primary school. ([F], [P])

In summary, students in the interviews thought that endocrine system, topics related with plants, tissues, photosynthesis, respiration are difficult topics to learn. Interdisciplinary and abstract nature of the concepts, terminology, rote-memorization are the factors causing difficulty in learning the topics.

4.2.2.2. Teacher Interview Results

A total number of 4 (2 female, 2 male) high school biology teacher were interviewed. Their years of experience ranged from 1 to 20 years, with more than 73% having more than 5 years of experience.

The first question was "At which topics do your students have difficulty and why?" Selected examples are given below.

> Students have difficulty in tissues because it is complicated and many new terms are introduced to the students. Another reason is that they cannot establish a relationship between the tissues and their previous knowledge. (male [M], private school [P], 2 years of experience [y.o.e.])

> Students have difficulty in hormones because we are giving all hormones together. In this system, students have to know the anatomical structure. Which organ is at which place, what is the function of each organ, hormones are synthesized at which gland? For this reason, students try to memorize all the

> things instead of understand them. However, we have to follow another sequence in the instruction of systems. For example, we may give the reproductive system firstly and then the hormones. By this way, students can easily understand the function of hormones. Also, students had difficulty in respiration, photosynthesis because these topics are abstract. There are many chemical steps they have to follow. ([F, P, 19 y.o.e.])

> Students have problems in biotechnology because of time limitations. The topic is at the end of the curriculum and it is given at the end of 11^{th} grade. There is less time to teach it. In order to complete the curriculum, the concept is given to the students superficially. For this reason, it cannot be understood. In addition, since ÖSS is so close at this time, some of teachers prefer to make review instead of teaching biotechnology. The other point is about the students, for the same reason they are not interested in the concept. They prefer to solve questions asked in ÖSS. ([M, P, 3 y.o.e.])

The second question was "What are the sources of difficulty in biology?" One teacher explained all of the possible sources well. The other teachers were agreeing with her.

> The first reason that students think biology requires rote-memorization. However, it is not like this because it needs logic. Students have to understand the relationships between events. Secondly, The sequence of concepts is very important. For example, transport system should be given before the digestive system and respiratory system. Otherwise, students would have problems in all of the topics. Thirdly, topics in biology are interrelated. If students have a problem in one of the topics, than they have difficulty in other topics. For example, if the student has difficulty in osmosis, then he has problem in excretory system, transport system

also. Due to visualization, students have difficulty. ([F, P, 19 y.o.e.])

As a summary, teachers stated during interviews that tissues, endocrine systems, biotechnology are difficult concepts fir their students. The sources of difficulty were interdisciplinary and abstract nature of the concepts, time limitation, terminology and sequence of topics in the curriculum according to the teachers.

CHAPTER 5

DISCUSSION

This study aimed to determine what content in biology was perceived as difficult and important for high school students to learn and whether there is a relationship between the variables of the study: reasoning ability, gender, perceived difficulty and importance. In this chapter, a summary of the study, conclusions, discussion about the results and implications for practice and future studies.

5. 1. Discussion

Results of this study revealed that students have difficulty in biotechnology, endocrine system (hormones), photosynthesis, respiration, gene, allele, Mendelian genetics, reproduction in animals, nervous system in vertebrates. In addition, producers, consumers and decomposers, food pyramid, active transport, biotic and abiotic factors in an ecosystem and scientific method were classified as easy topics in high school biology curriculum. The results of teachers and students are the same about the difficult and easy topic, which means that teachers are aware of the problems of their students in biology. These findings are in agreement with many of the finding reported in the literature (Bahar et al., 1999, Finley et al., 1982).

In addition to the perceived difficulty, the important topics in high school biology topics were investigated in the study. Students and teachers classified reproduction in animals, protein synthesis, respiration, DNA, gene, meiosis, chromosome and the cell as important topics in the high school biology

curriculum. While body systems in invertebrates were put into less important categories, body systems in vertebrates were categorized as important.

Also, results revealed that statistically significant negative correlation between perceived difficulty and importance for students. (r= -.147, p= 0.03). It means that when difficulty level of a topic increases, importance level of the topic decreases. In other words, students perceived the topics unimportant if they have difficulty in understanding it. On the other hand, photosynthesis, respiration, gene and meiosis were classified as important and difficult concepts. These topics have been chosen as important in spite of their difficulty, because these are thought to be fundamental concepts for the whole biology curriculum and most frequently asked questions in ÖSS. However, no statistically significant relationship was found between perceived difficulty and importance from the results of teachers (r= -.208, p=0.439). It means that importance of a concept does not depend on the difficulty according to the teachers. This may be because teachers believe that some difficult topics are not necessarily important to teach such as animal tissues. Another finding of the study was the negative correlation between students' perceived difficulty and reasoning ability (r=- . 119, p=. 018). In other words, students having low reasoning ability perceive the topics in biology as difficult. This finding was supported by many researches. For example, Ehindero (1979) indicated that reasoning ability level of students and achievement in biology are related to each other. The studies of Lazarowitz and Penso (1992), Cavallo (1996) and Smith and Sims (1992) supported the negative correlation between students' perceived difficulty and reasoning ability. However, there was no relationship between reasoning ability and importance (r= . 30, p=. 554). It would appear that cognitive development has no influence on importance level of topics. If the results of teachers were examined, no statistically significant relationship between perceived difficulty and years of experience of teachers (r= -. 113, p=. 677) was obtained. This result was not expected at the beginning of the study because experienced teachers know difficulties of students. The reason may be due to the number of teachers and the distribution of experience. On the contrary, the results revealed that there was a positive relationship between importance and years of experience of teachers (r= . 618, p=. 011). It means that more experienced teachers know the important topics in the biology more

effectively. However, about 38.4 % of variation in importance level was explained by the teachers' years of experience, which is very weak variance. In addition, there was no statistically significant relationship between perceived difficulty and faculty of graduation of teachers (r= .244, p= .363) and importance and faculty of graduation of teachers (r= - .173, p= .522). It means that the teachers' view about the difficulties of students and importance level of topics do not depend on the faculty that they graduated.

Data obtained through interviews and questionnaire revealed that difficulties often originate from the presence of foreign terminology, structure of the curriculum, abstract and interdisciplinary nature of concepts, the necessity to integrate knowledge from several sources, textbooks, the way in which concept is presented. There seems to be a problem with the biology curriculum in Turkish high schools in terms of quantity of subject matter to be covered. The curriculum is prescriptive, not enough time was given to each topic to study deeply. Besides, time allocated to biology is less than that of other science related subjects. It is 2 hour/week in 9^{th} and 10^{th} grades and 3 hours/week in 11^{th} grade. Students, however, are continuously being introduced new terminology and concepts. Therefore, they tend to memorize concepts rather than learn them meaningfully and fail to realize biology as a science which involves formulating hypotheses, making observations, conducting experiments, drawings conclusions, and evaluating results. Another factor that contributes occurrence of difficulties is lack of prerequisite knowledge. Certain prerequisite concepts are necessary for a learner to develop understanding of a certain concept. If these do not exist, it would be difficult for the learner to understand the new concept. About one-forth of the responded agreed that lack of prerequisite knowledge creates difficulties in learning biology.

Many researchers discussed the causes behind these difficulties. Stern and Roseman (2003), for example, stated that textbooks are important for science teaching because they largely determine what topics and ideas are taught in the classrooms and how these topics are taught. They gave the examples in the textbooks about the topics photosynthesis, cellular respiration and energy transformations between organisms and their physical settings. They stated that textbooks fail to tie together different relevant experiences that students

have with the key ideas: the food making process, for instance, is often treated in one chapter whereas a different chapter focuses on plant anatomy and explains that food is stored in certain plants' parts. No explanation, however, is provided for where this stored food comes from and how it relates to the photosynthesis process. In neither place is the incorporation of sugars into the plant's body structured. In addition, materials in photosynthesis and respiration often focus on naming reactants and products rather than on the concept of energy transformation. In the absence of an emphasis on transformation, students see plants (or any other living organisms) as taking in and using some substances and producing some others as separate events, not appreciating that substances taken in are raw materials for the products. Another problem related to textbooks according to their study is that most key ideas are introduced several times in each of the materials, but are often buried between unrelated ideas, making it difficult for students to focus on the main ideas. In addition, Tolman (1982) suggested that the difficulty in relating the concepts of meiosis and genetics came from the sequence in which these topics were presented in biology textbooks. Stewart (1983), and Cho, Kahle and Nordland (1985) stressed the importance of relationships between the concept of meiosis and genetics and the ambiguous and incorrect use of genetics concepts in textbooks. Concepts in textbooks are often inappropriate for the grade level at which they are aimed, and mismatched to what students know and can learn. Many concepts are too difficult for students even at much higher-grade levels. These points are also true for the Turkish biology textbooks. In addition, biological terms are directly translated to Turkish language according to their pronunciation. Some of the textbooks use the translated terms meanwhile some of them use a Turkish name for the same term; for example "ksilem" and "odun borusu" are both used for xylem. This generates confusion in students' minds. Also, the illustrations in textbooks are rare and lack clarity that causes misconceptions. Moreover, details that should be given at university level are introduced in Turkish high school textbooks.

In additions to textbooks, Eisen and Stavy (1992) identified several difficulties that students experience in learning photosynthesis. They claimed that these difficulties originated from inadequate knowledge in three domains-chemistry, biology and physics and structure of curriculum. They suggested that

the curriculum should deal with photosynthesis on a more general level. Besides, many researchers have investigated the importance of figures in the biology textbooks (see Kearsey & Turner, 1999). They suggested that the figures presented in a textbook have important roles in the explanation, conceptualization and illustration of the text. These studies also showed that learning from the text in biology is enhanced by the presence of figures. Therefore, improvements to the figures in the textbooks are necessary to reduce students' difficulties.

Regarding students' cognitive stages, findings of this study indicated that majority of the high school students are not formal reasoners. However, most of the biology topics, such as photosynthesis, respiration, co-dominance and sex linkage were identified as being on an abstract level in biology curricula (Lawson and Renner 1975) and require formal reasoning. They stated that students defined as concrete operational reasoners encounter learning difficulties when they were asked to deal with concepts which require formal reasoning (Lawson and Renner 1975). Therefore students' ability to cope with formal concepts in a meaningful manner is correlated with their level of intellectual developments. Present study is consisted with this view. A statistically significant negative correlation was found between students' reasoning ability and their perceived difficulty. Students, who are at higher cognitive level, have less difficulty in learning biology. However, it was expected that formal students who no longer require concrete objects to make rational judgments and are capable of hypothetical and deductive reasoning would perform better than transitional and concrete student. What is more, Lawson and Renner (1975) demonstrated that while concrete-operational students were able to understand only concrete concepts, formal-operational students were able to understand both concrete and formal concepts. As Lawson and Thompson (1988) pointed out formal operational students possessing the formal patterns necessary for evaluating competing hypothesis by comparing the predicted outcomes can overcome biological misconceptions which interfere with further, meaningful learning. On the other hand, concrete operational students continue to use their misconceptions to make predictions failing to recognize the limitations of these misconceptions and appreciate the merits of the scientific conception. To be able to promote meaningful learning, help students abstract key concepts, realize

the interrelationships among the concepts, transfer and integrate what they learn in one course to another and to their daily lives, teachers should be aware of the reasoning ability of their students and design the lesson accordingly. For example, concrete students can be instructed with instructional materials that provide first-hand experiences and concrete problems (Lawson and Renner, 1975). Nevertheless, it should be noted that such materials could be inadequate for cognitively precocious students who are capable of assimilating abstract instructional materials (Ehindore, 1979). Also, Ugwu and Soyibo (2004) stated that the equipment and materials needed for students' practical activities are adequate and in good working condition, as the lack of and inadequacy of, science teaching facilities in developing nations has been implicated as one of the main causes of students, poor science performance. Thus, teachers should provide a rich learning environment for the students to deal with individual differences. Also, to foster formal operations, teachers should pose problem to students and present them with questions and conflicting situations, and encourage them to analyze their own thinking either individually or in groups (Mwamwenda, 1993). Moreover, it is suggested that courses should be taught by learning cycle (Bitner, 1991) and inquiry (Johnson and Lawson, 1998), which foster scientific reasoning. Johnson and Lawson (1998) reported that the ability of prior knowledge and reasoning ability to be the factors, which can predict academic achievement, depending on the instructional procedure used. They showed that reasoning ability might limit the academic achievement of biology students, instructed either in expository or inquiry methods. However, Stern (2003) suggested that the persistence of some commonly held ideas reported in the literature are not necessarily the lack of reasoning abilities or age relatedness of students but more likely the result of poor curricula and instruction. The strategies, which teachers adopt to deliver instruction also effect students' learning.

5.1. Implications of the Study

5.1.1. Implications for the Education In Practice

Possible sources of students' difficulties in learning can be attributed mainly to the high school biology curriculum, teaching-learning strategies, textbooks,

and lack of laboratory sessions. In addition, students' motivation and interest must be also taken into consideration. Students had difficulties in learning some subjects and had no interest in the lesson because high school biology curriculum did not include subject matter relevant to daily life. There is a necessity for making the subject matter of high school biology curriculum more contemporary, meaningful and interesting for the students, reflecting the recent developments in the field to the curriculum and relating lessons with daily life issues. Moreover, textbooks are the curricular material most commonly used for the teaching of biology at every educational level. Therefore it is important to analyze how concepts of biology are introduced by them.

Studies indicated that concepts taught must be matched to the developmental level of the students. This study also suggests major shifts in curriculum to better fit content with the intellectual development of the learner. A substantial portion of the high school biology curriculum seems be not suitable in terms of the intellectual level of the students.

To sum up, biology courses must be supported by qualified textbooks, instructional materials, laboratory sessions and observation and experiments that actively engage students in learning processes. Therefore, biology needs to be taught dynamically, not as a static subject in textbooks, emphasizing inquiry instruction allowing students to pursue areas of personal interest.

Given that many topics typically taught in secondary school involve unobservable theoretical entities and processes (e.g. genes, osmosis, PS) additional insight into these issues should help instructional design aimed at improving hypothesis-testing skills.

5.1.1. Implications for the Research

Although the results of the study accounts for only 12.1% of the target population, results of the study are strongly supported by literature. For this reason the study should be revised with a large sample size.

This study gives insights about difficulties of students in high school biology curriculum, but it is evident that many more studies should be conducted in the light of this study. For example, it is needed to reveal the sources of difficulty at each topic specifically such as in genetics, photosynthesis. Also, textbooks used in Turkish high school at each difficult topic may be examined. Also, drawings and contexts in the textbooks analyzed in detail. In addition, another investigation may be about the sequence of topics in the curriculum. Unnecessary material and details may be examined and by the is way reconstruction of the curriculum may be studied. Terminology may be another area of research. Alternative ways of using specific terms may be studied. Development of teaching methods may be developed for especially for transitional and cognitive students in order to cure the problems in understanding different topics in biology.

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APPENDIX A

Table A.1. Descriptive Statistics For Difficult Topics Selected By Students

Topics	5	4	3	2	1	Mean	S. D.
Scientific method	1.8	4.8	10.1	28.5	54.9	1,7	1,0
Enzyme	3.8	12.6	30.0	35.8	17.9	2,5	1,0
Cell	5,3	15,9	33,8	27,2	17,9	2,6	1,1
Osmosis	5,0	7,6	24,4	35,0	28,0	2,3	1,1
Active transport	3,5	8,1	21,9	38,0	28,5	2,2	1,1
Endocytosis	2,8	9,1	25,9	35,0	27,2	2,3	1,0
Mitosis	7,3	20,2	34,3	23,9	14,4	2,8	1,1
Meiosis	7,6	25,9	36,5	18,4	11,6	3,0	1,1
Photosynthesis	16,1	23,4	29,5	18,4	12,6	3,1	1,2
Respiration	16,1	21,9	29,5	21,7	10,8	3,1	1,2
Gene	15,9	23,4	28,2	20,7	11,8	3,1	1,2
Allele	13,9	20,4	34,8	17,6	13,4	3,0	1,2
Chromosome	8,6	21,2	41,1	16,9	12,3	3,0	1,1
DNA	8,6	20,7	35,3	19,4	16,1	2,9	1,2
Classification	7,3	10,1	23,9	32,5	26,2	2,4	1,2
Biotic and abiotic factors in an ecosystem	4,3	9,1	21,9	31,7	33,0	2,2	1,1
Producers. consumers and decomposers	4,0	7,1	28,0	30,2	30,7	2,2	1,1
Food Pyramid	4,0	12,1	19,1	31,5	33,2	2,2	1,2
Matter cycles	8,8	19,6	31,5	24,9	15,1	2,8	1,2
Plant tissues	8,8	21,9	34,0	22,7	12,6	2,9	1,1
Animal tissues	9,6	20,4	36,5	21,4	12,1	2,9	1,1
Nervous system in invertebrates	11,1	18,6	36,3	21,9	12,1	2,9	1,2
Nervous system in vertebrates	12,6	22,9	36,3	18,1	10,1	3,1	1,1
Plant hormones	15,9	18,6	33,0	21,2	11,3	3,1	1,2
Animal hormones	22,7	20,7	28,2	18,6	9,8	3,3	1,3
Skeletal system	7,8	18,9	39,5	21,7	12,1	2,9	1,1
Digestive system in invertebrates	7,8	16,4	38,8	22,7	14,4	2,8	1,1
Digestive system in vertebrates	9,1	20,9	39,3	20,2	10,6	3,0	1,1
Transport system in invertebrates	9,1	16,4	37,0	23,9	13,6	2,8	1,1
Transport system in vertebrates	7,3	23,4	32,0	25,4	11,8	2,9	1,1
Respiratory system in invertebrates	6,3	15,6	38,5	25,7	13,9	2,7	1,1
Respiratory system in vertebrates	8,6	18,6	34,5	25,4	12,8	2,8	1,1
Excretory system in invertebrates	8,8	16,4	37,5	22,7	14,6	2,8	1,1
Excretory system in vertebrates	9,3	21,4	36,8	21,7	10,8	3,0	1,1

Table A.1. contiuned.

Topics	5	4	3	2	1	Mean	S. D.
Protein synthesis	13,1	20,9	32,0	20,7	13,4	3,0	1,2
Asexual reproduction	7,3	15,4	32,5	24,9	19,9	2,7	1,2
Reproduction of flowering plants	9,1	18,4	31,5	25,7	15,4	2,8	1,2
Reproduction in animals	13,9	22,2	28,0	22,2	13,9	3,0	1,2
Development in plants	8,8	15,6	33,8	28,7	13,1	2,8	1,1
Development in animals	9,8	16,6	36,5	23,7	13,4	2,9	1,1
Mendelian genetics	13,9	24,4	28,0	20,4	13,4	3,1	1,2
Biotechnology	25,4	25,4	26,2	13,1	9,8	3,4	1,3

5: very difficult 4: difficult 3: moderate 2: easy 1: very easy

APPENDIX B

Table B.1. Descriptive Statistics For Important Topics Selected By Students

Topics	5	4	3	2	1	Mean	S. D.
Scientific method	19,6	13,9	32,0	18,6	15,9	3,0	1,3
Enzyme	33,8	34,8	21,4	5,8	4,3	3,9	1,1
Cell	49,6	24,9	16,4	4,0	5,0	4,1	1,1
Osmosis	28,5	28,0	27,2	11,3	5,0	3,6	1,2
Active transport	26,4	26,7	27,2	15,4	4,3	3,6	1,2
Endocytosis	20,2	22,2	31,2	18,9	7,6	3,3	1,2
Mitosis	45,8	25,7	14,9	7,3	6,3	4,0	1,2
Meiosis	47,1	28,2	12,6	6,5	5,5	4,0	1,2
Photosynthesis	51,6	25,7	10,6	5,5	6,5	4,1	1,2
Respiration	51,9	28,7	11,1	4,5	3,8	4,2	1,1
Gene	52,1	25,4	15,1	3,5	3,8	4,2	1,1
Allele	36,5	27,0	22,2	7,3	7,1	3,8	1,2
Chromosome	46,9	28,2	15,4	4,8	4,8	4,1	1,1
DNA	62,0	20,4	9,8	2,8	5,0	4,3	1,1
Classification	28,0	23,7	22,9	15,6	9,8	3,4	1,3
Biotic and abiotic factors in an ecosystem	18,9	20,4	29,5	18,4	12,8	3,1	1,3
Producers. consumers and decomposers	22,7	26,4	32,2	10,6	8,1	3,5	1,2
Food Pyramid	23,7	26,4	30,2	12,6	6,8	3,5	1,2
Matter cycles	30,0	26,7	21,7	12,8	8,8	3,6	1,3
Plant tissues	19,1	27,5	28,2	13,1	12,1	3,3	1,3
Animal tissues	23,2	29,0	25,4	9,6	12,8	3,4	1,3
Nervous system in invertebrates	19,1	24,7	25,7	15,4	15,1	3,2	1,3
Nervous system in vertebrates	35,0	27,7	21,7	8,1	7,6	3,7	1,2
Plant hormones	21,9	18,9	28,7	18,1	12,3	3,2	1,3
Animal hormones	38,0	27,7	17,1	10,3	6,8	3,8	1,2
Skeletal system	28,0	28,2	30,0	9,1	4,8	3,7	1,1
Digestive system in invertebrates	20,2	18,6	31,2	16,6	13,4	3,2	1,3
Digestive system in vertebrates	33,5	27,5	23,9	8,6	6,5	3,7	1,2
Transport system in invertebrates	22,7	21,2	26,2	17,6	12,3	3,2	1,3
Transport system in vertebrates	42,3	26,7	18,6	6,5	5,8	3,9	1,2
Respiratory system in invertebrates	21,7	23,9	28,5	14,6	11,3	3,3	1,3
Respiratory system in vertebrates	42,1	28,7	17,4	6,0	5,8	4,0	1,2
Excretory system in invertebrates	19,9	18,4	30,2	17,9	13,6	3,1	1,3

Table B.1. contiuned.

Topics	5	4	3	2	1	Mean	S. D.
Excretory system in vertebrates	41,6	26,2	19,4	6,5	6,3	3,9	1,2
Protein synthesis	52,1	21,9	15,6	5,3	5,0	4,1	1,2
Asexual reproduction	25,2	23,9	24,7	15,6	10,6	3,4	1,3
Reproduction of flowering plants	23,2	19,9	27,2	16,9	12,8	3,2	1,3
Reproduction in animals	47,1	24,2	16,6	6,3	5,8	4,0	1,2
Development in plants	22,2	23,2	28,0	15,9	10,8	3,3	1,3
Development in animals	34,8	29,5	22,7	7,6	5,5	3,8	1,2
Mendelian genetics	38,0	22,9	17,9	12,3	8,8	3,7	1,3
Biotechnology	50,9	21,2	13,1	6,5	8,3	4,0	1,3

5: very important
4: important
3: moderate
2: not important
1: not very important

APPENDIX C

Table C.1. Descriptive Statistics For Difficult Topics Selected By Teachers

Topics	5	4	3	2	1	Mean	S. D.
Scientific method	0	13	19	56	13	2,3	0,9
Enzyme	0,0	25,0	25,0	50,0	0,0	3,3	0,9
Cell	0,0	31,3	37,5	31,3	0,0	3,0	0,8
Osmosis	6,3	56,3	31,3	6,3	0,0	3,6	0,7
Active transport	0,0	68,8	18,8	12,5	0,0	3,6	0,7
Endocytosis	6,3	31,3	37,5	25,0	0,0	2,8	0,9
Mitosis	12,5	50,0	31,3	12,5	0,0	3,5	0,8
Meiosis	50,0	37,5	12,5	0,0	0,0	4,4	0,7
Photosynthesis	43,8	37,5	12,5	6,3	0,0	4,2	0,9
Respiration	43,8	43,8	12,5	0,0	0,0	4,3	0,7
Gene	12,5	18,8	43,8	25,0	0,0	3,2	1,0
Allele	25,0	12,5	37,5	25,0	0,0	3,4	1,1
Chromosome	18,8	18,8	37,5	25,0	0,0	3,3	1,1
DNA	18,8	31,3	31,3	18,8	0,0	3,5	1,0
Classification	6,3	18,8	62,5	12,5	0,0	3,2	0,8
Biotic and abiotic factors in an ecosystem	0,0	6,3	18,8	62,5	12,5	2,2	0,8
Producers. consumers and decomposers	0,0	6,3	18,8	56,3	18,8	2,1	0,8
Food Pyramid	0,0	6,3	25,0	50,0	18,8	2,2	0,8
Matter cycles	6,3	18,8	56,3	18,8	0,0	2,9	0,8
Plant tissues	18,8	50,0	18,8	12,5	0,0	3,8	0,9
Animal tissues	18,8	43,8	25,0	12,5	0,0	3,7	0,9
Nervous system in invertebrates	12,5	31,3	37,5	18,8	0,0	3,4	1,0
Nervous system in vertebrates	31,3	43,8	25,0	0,0	0,0	4,1	0,8
Plant hormones	18,8	50,0	25,0	6,3	0,0	3,8	0,8
Animal hormones	50,0	43,8	6,3	0,0	0,0	4,4	0,6
Skeletal system	0,0	43,8	50,0	6,3	0,0	3,4	0,6
Digestive system in invertebrates	6,3	25,0	43,8	25,0	0,0	3,1	0,9
Digestive system in vertebrates	18,8	50,0	25,0	6,3	0,0	3,8	0,8
Transport system in invertebrates	0,0	31,3	43,8	25,0	0,0	3,1	0,8
Transport system in vertebrates	25,0	6,3	56,3	12,5	0,0	3,4	1,0
Respiratory system in invertebrates	0,0	31,3	31,3	37,5	0,0	2,9	0,9
Respiratory system in vertebrates	6,3	6,3	62,5	25,0	0,0	2,9	0,8
Excretory system in invertebrates	0,0	31,3	37,5	31,3	0,0	3,0	0,8
Excretory system in vertebrates	25,0	37,5	31,3	6,3	0,0	3,8	0,9

Table C.1. contiuned.

Protein synthesis	18,8	50,0	25,0	0,0	6,3	3,8	1,0
Asexual reproduction	6,3	6,3	62,5	25,0	0,0	2,9	0,8
Reproduction of flowering plants	6,3	43,8	43,8	6,3	0,0	3,5	0,7
Reproduction in animals	31,3	31,3	31,3	6,3	0,0	3,9	1,0
Development in plants	6,3	43,8	50,0	0,0	0,0	3,6	0,6
Development in animals	6,3	50,0	43,8	0,0	0,0	3,6	0,6
Mendelian genetics	18,8	31,3	43,8	6,3	0,0	3,6	0,9
Biotechnology	18,8	25,0	50,0	0,0	6,3	3,5	1,0

5: very difficult 4: difficult 3: moderate 2: easy 1: very easy

APPENDIX D

Table D.1 Descriptive Statistics For Important Topics Selected By Teachers

Topics	5	4	3	2	1	Mean	S. D.
Scientific method	56,3	18,8	12,5	12,5	0	4,2	1,1
Enzyme	87,5	12,5	0,0	0,0	0,0	4,9	0,3
Cell	93,8	6,3	0,0	0,0	0,0	4,9	0,3
Osmosis	75,0	18,8	6,3	0,0	0,0	4,7	0,6
Active transport	68,8	25,0	6,3	0,0	0,0	4,6	0,6
Endocytosis	50,0	37,5	6,3	6,3	0,0	4,3	0,9
Mitosis	81,3	12,5	6,3	0,0	0,0	4,8	0,6
Meiosis	87,5	6,3	6,3	0,0	0,0	4,8	0,5
Photosynthesis	75,0	18,8	6,3	0,0	0,0	4,7	0,6
Respiration	75,0	12,5	12,5	0,0	0,0	4,6	0,7
Gene	43,8	56,3	0,0	0,0	0,0	4,4	0,5
Allele	31,3	62,5	6,3	0,0	0,0	4,3	0,6
Chromosome	43,8	56,3	0,0	0,0	0,0	4,4	0,5
DNA	50,0	50,0	0,0	0,0	0,0	4,5	0,5
Classification	18,8	37,5	37,5	6,3	0,0	3,7	0,9
Biotic and abiotic factors in an ecosystem	18,8	56,3	6,3	18,8	0,0	3,8	1,0
Producers. consumers and decomposers	37,5	62,5	0,0	0,0	0,0	4,4	0,5
Food Pyramid	43,8	50,0	6,3	0,0	0,0	4,4	0,6
Matter cycles	50,0	37,5	6,3	6,3	0,0	4,3	0,9
Plant tissues	6,3	25,0	50,0	18,8	0,0	3,2	0,8
Animal tissues	0,0	25,0	50,0	12,5	12,5	2,9	1,0
Nervous system in invertebrates	25,0	25,0	6,3	31,3	12,5	3,2	1,5
Nervous system in vertebrates	31,3	68,8	0,0	0,0	0,0	4,3	0,5
Plant hormones	25,0	31,3	25,0	18,8	0,0	3,6	1,1
Animal hormones	50,0	37,5	12,5	0,0	0,0	4,4	0,7
Skeletal system	31,3	50,0	12,5	6,3	0,0	4,1	0,9
Digestive system in invertebrates	6,3	18,8	25,0	50,0	0,0	2,8	1,0
Digestive system in vertebrates	31,3	50,0	6,3	12,5	0,0	4,0	1,0
Transport system in invertebrates	12,5	12,5	25,0	50,0	0,0	2,9	1,1
Transport system in vertebrates	62,5	37,5	0,0	0,0	0,0	4,6	0,5

Table D.1. contiuned.

Respiratory system in invertebrates	12,5	12,5	25,0	50,0	0,0	2,9	1,1
Respiratory system in vertebrates	75,0	25,0	0,0	0,0	0,0	4,8	0,4
Excretory system in invertebrates	6,3	18,8	43,8	31,3	0,0	3,0	0,9
Excretory system in vertebrates	68,8	31,3	0,0	0,0	0,0	4,7	0,5
Protein synthesis	75,0	25,0	0,0	0,0	0,0	4,8	0,4
Asexual reproduction	6,3	56,3	25,0	12,5	0,0	3,6	0,8
Reproduction of flowering plants	18,8	37,5	31,3	12,5	0,0	3,6	1,0
Reproduction in animals	75,0	25,0	0,0	0,0	0,0	4,8	0,4
Development in plants	18,8	25,0	37,5	18,8	0,0	3,4	1,0
Development in animals	43,8	50,0	6,3	0,0	0,0	4,4	0,6
Mendelian genetics	68,8	18,8	12,5	0,0	0,0	4,6	0,7
Biotechnology	31,3	43,8	18,8	6,3	0,0	4,0	0,9

5: very important
4: important
3: moderate
2: not important
1: not very important

APPENDIX E

STUDENT QUESTIONNAIRE

Değerli Öğrenci,

Bu anket **Biyoloji dersinde** zorlandığınız konularda sizin düşüncenizi almak amacıyla düzenlenmiştir.

Ölçek üç bölümden oluşmuştur:

- Birinci bölüm size ait kişisel bilgilerden oluşmaktadır.
- İkinci bölüm Biyoloji derslerinde anlatılmakta olan konuların zorluk ve önem derecesini belirlemektedir.
- Son bölüm ise, konuların önem ve zorluklarının nedenlerini araştırmaktadır.

Lütfen hiçbir soruyu boş bırakmayınız.

İlginiz için teşekkürler...
Hülya KABLAN
Yüksek Lisans Öğrencisi, ODTÜ

BİRİNCİ BÖLÜM: KİŞİSEL BİLGİLER

1. Cinsiyet: ☐ Kız ☐ Erkek
2. Yaş: _____

3. Okul: _____

4. Geçen yılki biyoloji karne notunuz: _____

5. Biyoloji dersine karşı olan ilginiz: (Lütfen bir tanesini işaret-leyiniz)

☐ Biyoloji dersini çok seviyorum.
☐ Biyoloji dersini seviyorum.
☐ Biyoloji dersini orta derecede seviyorum.
☐ Biyoloji dersini sevmiyorum.
☐ Biyoloji dersini hiç sevmiyorum.

İKİNCİ BÖLÜM:

Bu bölüm iki boyutta hazırlanmıştır. Birinci boyutta hangi konularda zorlandığınız; ikinci boyutta ise bu konuların sizce önem derecesi sorulmaktadır.
ÖRNEK:
Enzimler konusunu anlamakta zorlanıyorum : 4
Enzimler konusu bana göre çok önemli: 5

Önem Derecesi: **1:** Hiç Önemli Değil **2:** Önemli değil **3:** Orta derecede önemli **4:** Önemli **5:** Çok önemli						**Zorluk Derecesi:** **1:** Çok kolay **2:** Kolay **3:** Orta derecede zor **4:** Zor **5:** Çok zor				
Önem Derecesi					**Konular**	**Zorluk Derecesi**				
1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
					Bilimsel Yöntem					
					Enzimler					
					Hücre					
					Difüzyon ve Osmoz					
					Aktif Taşıma					
					Endositoz, Eksositoz					
					Mitoz Bölünme					
					Mayoz Bölünme					
					Fotosentez					
					Solunum					
					Gen					
					Alel					
					Kromozom					
					DNA					
					Canlıların Çeşitliliği ve Sınıflandırma					
					Çevrenin Canlı ve Cansız Etmenleri					
					Üreticiler, Tüketiciler ve Ayrıştırıcılar					
					Besin zinciri, Besin Ağı, Enerji Piramidi					
					Madde Döngüleri (Su, Karbon, Azot)					
					Bitkisel Dokular					
					Hayvansal Dokular					
					Omurgasızlarda Sinir Sistemi					
					Omurgalılarda Sinir Sistemi					
					Bitkisel Hormonlar					
					İnsanda Endokrin Bezler ve Hormonlar					
					Omurgalı Hayvanlarda Destek ve Hareket					

Önem Derecesi					Konular	Zorluk Derecesi				
1	2	3	4	5		1	2	3	4	5
					Omurgasızlarda Sindirim Sistemi					
					Omurgalılarda Sindirim Sistemi					
					Omurgasızlarda Dolaşım Sistemi					
					İnsanda Dolaşım Sistemi					
					Omurgasızlarda Solunum Sistemi					
					İnsanda Solunum Sistemi					
					Omurgasızlarda Boşaltım Sistemi					
					İnsanda Boşaltım Sistemi					
					Protein Sentezi					
					Eşeysiz Üreme					
					Çiçekli Bitkilerde Üreme					
					İnsanda Üreme Sistemi					
					Bitkilerde Büyüme ve Gelişme					
					Hayvanlarda Büyüme ve Gelişme					
					Mendel İlkeleri ve Uygulamaları					
					Biyoteknoloji ve Genetik Mühendisliği					

ÜÇÜNCÜ BÖLÜM:

1. Seçmiş olduğunuz konular sizce neden zor?
Aşağıda size yardımcı olabilecek bazı alternatif nedenler sıralanmıştır. Lütfen size göre uygun seçeneği veya seçenekleri işaretleyiniz (istediğiniz kadar işaretleyebilirsiniz).

☐ Ezbere dayalı olması
☐ Yabancı terminolojinin çok olması
☐ Yeterince zaman ayrılmaması
☐ Soyut olması
☐ İlgimi çekmemesi
☐ Konuların birbirleri ile bağlantılı olması
☐ Konuların görsel olmaması
☐ Günlük hayatla ilgili olmaması
☐ Yeterince deney yapılmaması
☐ Yeterince çalışmamam
☐ Ön bilgimin yetersiz olması

Başka bir nedeni varsa lütfen belirtiniz:

2. Bölüm II'de önemli olarak seçmiş olduğunuz konular, sizce neden önemli, lütfen belirtiniz.

3. Lütfen aşağıda sizin için uygun olan seçeneği işaretleyip nedenini açıklayınız.

☐ Genellikle bitkilerle ilgili konuları anlamakta zorlanıyorum.

☐ Genellikle hayvanlarla ilgili konuları anlamakta zorlanıyorum.

NEDENİ:

4. Biyoloji dersinde zorlandığınız ya da önemli olarak gördüğünüz başka konu eya düşünceleriniz var mı?

APPENDIX F

TEACHER QUESTIONNAIRE

Değerli Öğretmen,

Bu anket öğrencilerinizin **Biyoloji dersinde** zorlandıkları konularda sizin düşüncenizi almak amacıyla düzenlenmiştir.

Anket üç bölümden oluşmaktadır:

- Birinci bölüm size ait kişisel bilgilerden oluşmaktadır.
- İkinci bölüm biyoloji derslerinde anlatmakta olduğunuz konuların zorluk ve önem derecesini belirlemektedir.
- Son bölüm ise konuların önem ve zorluklarının nedenlerini araştırmaktadır.

Lütfen hiçbir soruyu boş bırakmayınız.

İlginiz için teşekkürler...

Hülya KABLAN
Yüksek Lisans Öğrencisi, ODTÜ

BİRİNCİ BÖLÜM: KİŞİSEL BİLGİLER

Cinsiyet: ☐ Bay ☐ Bayan

Deneyim: _____**(yıl)**

Mezun Olduğunuz Fakülte:

☐ Fen-Edebiyat Fakültesi ☐ Eğitim Fakültesi ☐ Diğer: (Lütfen belirtiniz)

Görev Yaptığınız Okul:

☐ Özel Okul ☐ Anadolu Lisesi ☐ Düz Lise ☐ Diğer: (Lütfen belirtiniz)

İKİNCİ BÖLÜM:

Bu bölüm iki boyutta hazırlanmıştır. Birinci boyutta öğrencilerinizin hangi konularda zorlandığı; ikinci boyutta ise, bu konuların sizce önem derecesi sorulmaktadır.
ÖRNEK:
Enzimler konusunu anlamakta zorlanıyorum : 4
Enzimler konusu bana göre çok önemli: 5

Önem Derecesi: **1:** Hiç Önemli Değil **2:** Önemli değil **3:** Orta derecede önemli **4:** Önemli **5:** Çok önemli						**Zorluk Derecesi:** **1:** Çok kolay **2:** Kolay **3:** Orta derecede zor **4:** Zor **5:** Çok zor				
Önem Derecesi					**Konular**	**Zorluk Derecesi**				
1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
					Bilimsel Yöntem					
					Enzimler					
					Hücre					
					Difüzyon ve Osmoz					
					Aktif Taşıma					
					Endositoz, Eksositoz					
					Mitoz Bölünme					
					Mayoz Bölünme					
					Fotosentez					
					Solunum					
					Gen					
					Alel					
					Kromozom					
					DNA					
					Canlıların Çeşitliliği ve Sınıflandırma					
					Çevrenin Canlı ve Cansız Etmenleri					
					Üreticiler, Tüketiciler ve Ayrıştırıcılar					
					Besin zinciri, Besin Ağı, Enerji Piramidi					
					Madde Döngüleri (Su, Karbon, Azot)					
					Bitkisel Dokular					
					Hayvansal Dokular					
					Omurgasızlarda Sinir Sistemi					
					Omurgalılarda Sinir Sistemi					
					Bitkisel Hormonlar					
					İnsanda Endokrin Bezler ve Hormonlar					
					Omurgalı Hayvanlarda Destek ve Hareket					

Önem Derecesi					Konular	Zorluk Derecesi				
1	2	3	4	5		1	2	3	4	5
					Omurgasızlarda Sindirim Sistemi					
					Omurgalılarda Sindirim Sistemi					
					Omurgasızlarda Dolaşım Sistemi					
					İnsanda Dolaşım Sistemi					
					Omurgasızlarda Solunum Sistemi					
					Insanda Solunum Sistemi					
					Omurgasızlarda Boşaltım Sistemi					
					İnsanda Boşaltım Sistemi					
					Protein Sentezi					
					Eşeysiz Üreme					
					Çiçekli Bitkilerde Üreme					
					İnsanda Üreme Sistemi					
					Bitkilerde Büyüme ve Gelişme					
					Hayvanlarda Büyüme ve Gelişme					
					Mendel İlkeleri ve Uygulamaları					
					Biyoteknoloji ve Genetik Mühendisliği					

ÜÇÜNCÜ BÖLÜM:

1. Seçmiş olduğunuz konuları sizce öğrenciler neden anlamada zorlanıyor?
Alternatif nedenlerden bazıları aşağıda verilmiştir. Lütfen size göre uygun seçeneği veya seçenekleri işaretleyiniz.

- ☐ Ezbere dayalı olması
- ☐ Yabancı terminolojinin çok olması
- ☐ Yeterince zaman ayrılmaması
- ☐ Soyut olması
- ☐ Konuların birbiri ile bağlantılı olması
- ☐ Konuların görsel olmaması
- ☐ Günlük hayatla ilgili olmaması
- ☐ Yeterince deney yapılmaması
- ☐ Öğrencilerin ön bilgisinin yetersiz olması

☐ **Başka bir nedeni varsa lütfen belirtiniz:**

2. Yukarıda bazı konuları önemli olarak seçmenizdeki nedeni lütfen belirtiniz.

3. Lütfen aşağıda sizin için uygun olan seçeneği işaretleyip açıklayınız.

☐ Öğrenciler genellike bitkilerle ilgili konularda zorlanıyor.

☐ Öğrenciler genellikle hayvanlarla ilgili konularda zorlanıyor.

NEDENİ:

4. Sizin anlatmakta zorlandığınız herhangi bir konu var mı? Varsa, nedenini lütfen belirtiniz.

APPENDIX G

GALT

GROUP TEST OF LOGICAL THINKING

Developed by:

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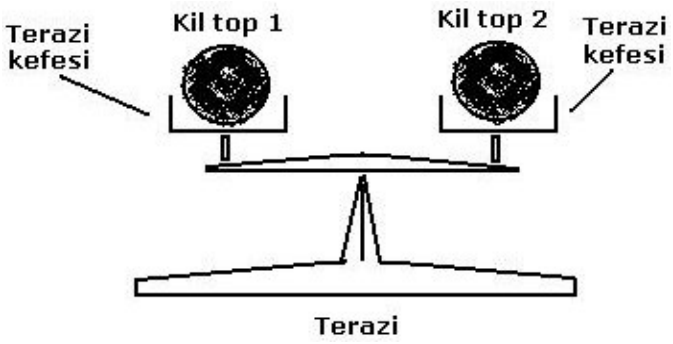
December 1982

Madde: 1

Kil top

Ali'nin aynı şekil ve büyüklükte iki kil topu vardır. Toplar teraziye konulduğunda aynı ağırlıkta gelmektedirler.



Kil toplar teraziden alınıp 2. kil top yassı bir gözleme şekline getirilmiştir.

Aşağıdaki cümlelerden hangisi doğrudur ?

a. Gözleme şeklindeki kil daha ağırdır.

b. İki kil parçası da eşit ağırlıktadır.

c. Top şeklindeki kil daha ağırdır.

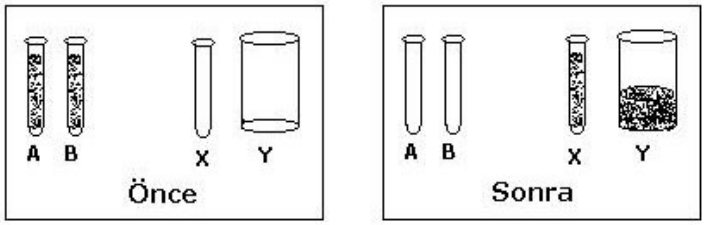
Sebep:

1. Kil arttırılmamış veya eksiltilmiştir.
2. Kil gözleme şekline getirildiğinde alanı daha büyük olmuştur.
3. Herhangi bir şey yassı hale getirildiğinde ağırlığı azalır.
4. Yoğunluğu nedeniyle top şeklinde olanda daha fazla kil vardır.

Madde: 2

Test tüpü

A ve B test tüpleri aynı miktarda su ile doludur. Aşağıda görüldüğü gibi, A tüpündeki su X tüpüne, B tüpündeki su ise Y kavanozuna dökülmüştür.



Aşağıdaki cümlelerden hangisi doğrudur ?

a. X tüpünde Y kavanozundan daha fazla su vardır.

b. Y kavanozunda X tüpünden daha fazla su vardır.

c. X tüpünde ve Y kavanozunda eşit miktarda su vardır.

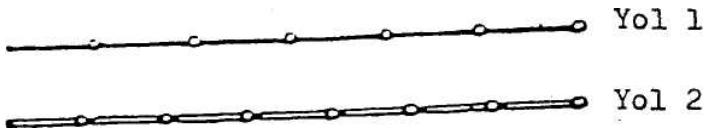
Sebep:

1. Y kavanozu X tüpünden daha geniş ve büyüktür.
2. Sular diğer kaplara boşaltılırken su ilave edilmemiş veya azaltılmamıştır.
3. Tüpün boyu ve kavanozun eni eşittir.
4. X tüpündeki suyun seviyesi Y kavanozundaki suyun seviyesinden daha yüksektir.

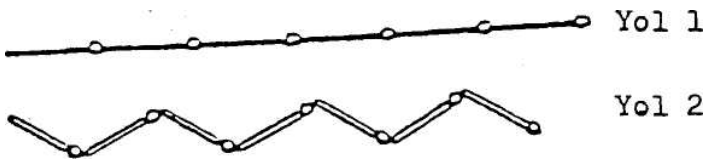
Madde: 3

Yol

Engin farklı kibritler kullanarak iki yol yapmıştır. Yollar aşağıdaki gibidir.



Engin daha sonra fikrini değiştirir ve 1. yolu aynı bırakıp, 2. yolu zigzag yapar.



Aşağıdaki cümlelerden hangisi doğrudur ?

a. 1. yol 2. yoldan daha uzundur.

b. 2. yol 1. yoldan daha uzundur.

c. 1. ve 2. yollar aynı uzunluktadır.

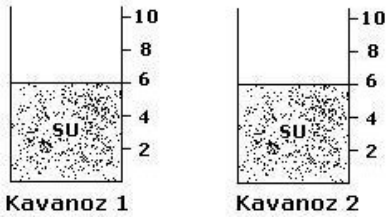
Sebep:

1. Düz gitmek, her zaman zigzag gitmekten daha kısadır.
2. Kibritlerin sayısı arttırılmamış veya eksiltilmemiştir.
3. 1. yol 6 kibritten, 2. yol 7 kibritten oluşmuştur.
4. Yol zigzag hale getirildiğinde düz halinden daha az yer tutar.

Madde: 4

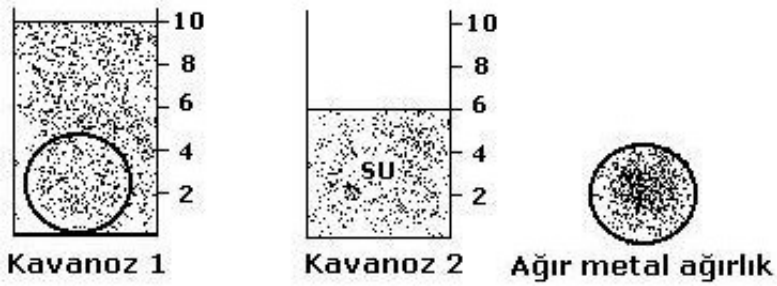
Metal Ağırlıklar

Ayşe'nin iki kavanozu vardır. Kavanozların büyüklükleri ve şekilleri aynıdır. Her iki kavanoz da aynı miktar su ile doldurulmuştur.



Ayşe'nin aynı zamanda iki metal ağırlığı vardır. Bunlardan biri ağır, diğeri hafiftir.

Ayşe hafif metal ağırlığı Kavanoz 1'e koyar ve kavanozdaki su seviyesi aşağıda görüldüğü gibi yükselir.



Kavanoz 2'ye ağır metal ağırlık konulduğunda ne olacaktır ?

a. Su seviyesi kavanoz 1'dekinden daha yüksek olacaktır.
b. Su seviyesi kavanoz 1'dekinden daha düşük olacaktır.
c. Su seviyesi kavanoz 1'deki kadar olacaktır.

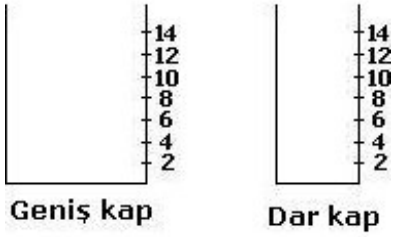
Sebep:

1. Ağırlıklar eşit büyüklükte olduklarına göre eşit miktarda yer kaplarlar.
2. Metal ağırlığın ağırlığı arttıkça su seviyesi daha fazla yükselecektir.
3. Ağır metal ağırlığın daha fazla basıncı olduğundan su daha az yükselecektir.
4. Metal ağırlığın ağırlığı arttıkça su seviyesi daha az yükselecektir.

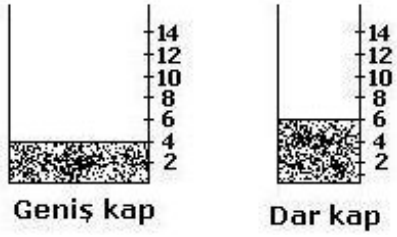
Madde: 5

Plastik kap # 1

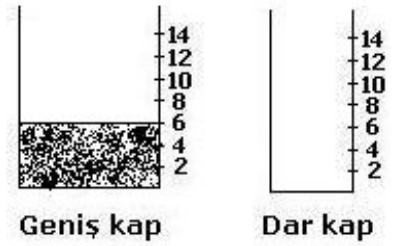
Biri geniş, diğeri dar iki plastik kap vardır.



Her kabın kenarı eşit aralıklara bölünmüştür. Ahmet her iki kaba da eşit miktarda su doldurur. Su seviyesi geniş kapta 4. işarete, dar kapta ise 6. işarete kadar gelir.



Ahmet geniş kaba daha büyük bardakla su doldurur ve su seviyesi 6 işarete kadar gelir.



Aynı miktar su dar kaba dökülseydi yüksekliği ne kadar olacaktı ?

a. 6 2/3 b. 8 c. 9 d. başka

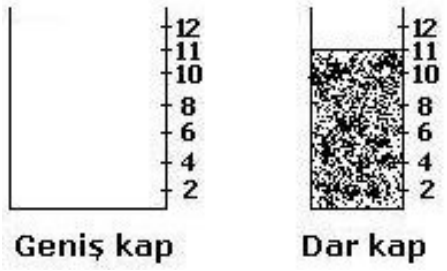
Sebep:

1. Geniş ve dar kaplara aynı miktarda su konulduğunda oranları her zaman 2 ye 3 olacaktır.
2. Su seviyesi geniş kapta 6 olduğunda dar kapta 2 işaret daha fazla olacaktır.
3. Dar ve geniş kaplardaki su oranı 2 ye 3 dür. Geniş kapta su seviyesi 6 ise, dar kapta 2/3 oranında daha fazla olacaktır.
4. Tahmin etmek mümkün değildir.

Madde: 6

Plastik kap # 2

Madde 5 deki aynı plastik kaplar kullanılmaktadır. Bu sefer Ahmet dar kaba bir bardak su koyar. Su seviyesi aşağıdaki şekilde görüldüğü gibi 11. işarete gelir.



Aynı miktar su geniş kaba döküldüğünde su seviyesi nerede olacaktır ?

a. 5 1/2
b. 7 1/3
c. 9
d. Başka

Sebep:

1. Su seviyesi dar kapta 11 ise geniş kapta bunun iki eksiği olacaktır.
2. Geniş kap dar kabın iki katı büyüklüğündedir.
3. Aynı miktar suyu geniş ve dar kaplara koyduğunuzda oran her zaman 3'e 2 olacaktır.
4. Tahmin etmek mümkün değildir.

Madde: 7

Bardak Büyüklüğü # 1

Aşağıdaki şekilde biri büyük biri küçük iki bardak ve biri büyük diğeri küçük iki kap görülmektedir.

Küçük kabı doldurmak için 6 büyük bardak veya 9 küçük bardak su gerekmektedir. Büyük kap ise 8 büyük bardakla dolmaktadır.

Büyük kabı doldurmak için kaç küçük bardak su gerekmektedir ?

a. 10

b. 11

c. 12

d. Başka

Sebep:

1. Büyük kabı doldururken büyük ve küçük bardak sular arasındaki fark daima 3 olacaktır.
2. Büyük kabı doldurmak için 2 küçük bardak su daha gerekmektedir.
3. Büyük bardaklardaki suyun küçük bardaklardaki suya oranı daima 2'ye 3 olacaktır.
4. Tahmin etmek mümkün değildir.

Madde: 8

Bardak büyüklüğü #2

Aşağıdaki şekilde biri küçük diğeri büyük iki bardak ve biri küçük diğeri büyük iki kap görülmektedir.

Büyük kabı doldurmak için 15 küçük veya 9 büyük bardak su gerekmektedir.

Küçük kap ise 10 küçük bardak su ile dolmaktadır.

Küçük kabı doldurmak için kaç büyük bardak su gerekmektedir ?

a. 4

b. 5

c. 6

d. Başka

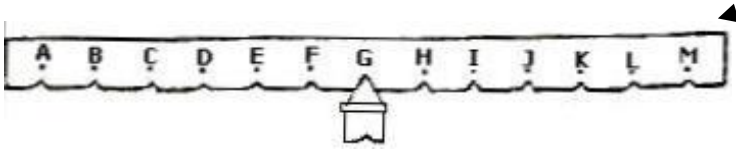
Sebep:

1. Küçük kabı doldurmak için 5 küçük bardak daha az su gereklidir. Öyleyse, aynı kabı doldurmak için 5 büyük bardak daha az sıvı gereklidir.
2. Büyük ve küçük bardakların oranı daima 5'e 3 olacaktır.
3. Küçük bardak büyük bardağın yarısı kadardır. Bu nedenle aynı küçük kap yaklaşık olarak büyük bardak sayısının yarısı kadar su ile tamamen dolar.
4. Tahmin etmek mümkün değildir.

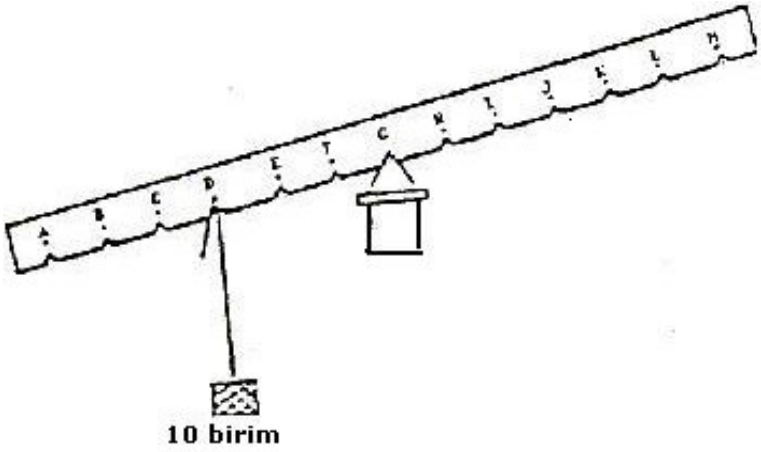
Madde: 9

Terazi # 1

Hasan'ın aşağıdaki gibi bir terazisi vardır. **Terazi**



Hasan D noktasına 10 birimlik bir ağırlık astığında terazi aşağıdaki gibi görünmektedir.



Teraziyi tekrar dengelemek için hasan 5 birimlik ağırlığı nereye aşmalıdır ?

a. J noktasına
b. K ve L arasına
c. L noktasına
d. L ve M arasına
e. M noktasına

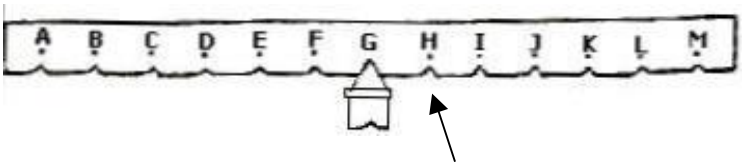
Sebep:

1. Asılacak ağırlık diğerinin yarısı kadar olduğuna göre iki misli uzağa yerleştirilmelidir.
2. 10 birim ağırlıkla aynı uzaklığa, ancak karşı istikamete.
3. 5 birimlik ağırlığın azlığını telafi etmek için uzağa asılmalı.
4. Terazi kolunun en sonuna asmak teraziye daha çok güç verir ve dengeler.
5. Ağırlık azaldıkça daha uzağa aşılmalıdır.

Madde: 10

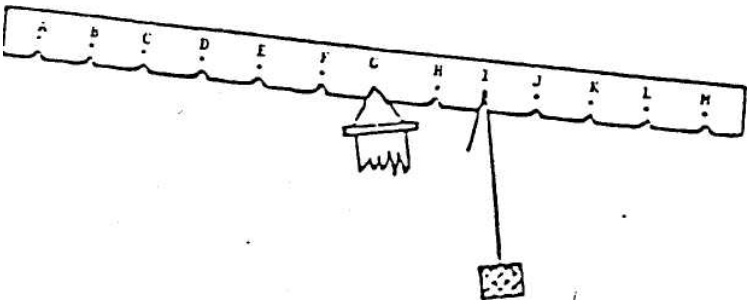
Terazi # 2

Meral'in aşağıdaki gibi bir terazisi vardır.



Terazi

Meral, teraziye I noktasında 15 birimlik bir ağırlık asar ve terazi aşağıdaki gibi görünür



15 birimlik ağırlık

Meral 10 birimlik ağırlığı nereye aşmalı ki terazisi tekrar dengede dursun ?

a. E noktasına
b. D noktasına
c. B noktasına
d. A ve B nin arasına
e. A noktasına

SEBEP:

1. 15 birim ağırlıkla aynı mesafeye, ancak karşı istikamete.
2. Terazi kolunun en sonu teraziyi dengelemek için daha çok güç verir.
3. 10 birim ağırlık 15 birim ağırlığın 2/3'ü dür. Öyleyse 15 birimlik ağırlığın karşı istikametine ve 3/2 si mesafeye yerleştirilidir.
4. 10 birimlik ağırlık küçüklüğünü telafi etmek için uzağa asılmalıdır.
5. Ağırlık azaldıkça daha uzağa asılmalıdır.

Madde: 11

Sarkaç uzunluğu

Bir çubuğa üç ip bağlanmıştır. 1. ve 3. ipler eşit uzunlukta, 2. ip ise daha uzundur. Yaşar 2. ve 3. iplerin uçlarına 5 birimlik, 1. ipin ucuna ise 10 birimlik bir ağırlık asar. Her ipin ucundaki ağırlıklar sallanabilmektedir.

Yaşar ipin ileri ve geri sallanma süresine ip uzunluğunun bir etkisi olup olmadığını bulmak istemektedir.

Bu deney için hangi ipi ve ağırlığı kullanması gerekmektedir ?

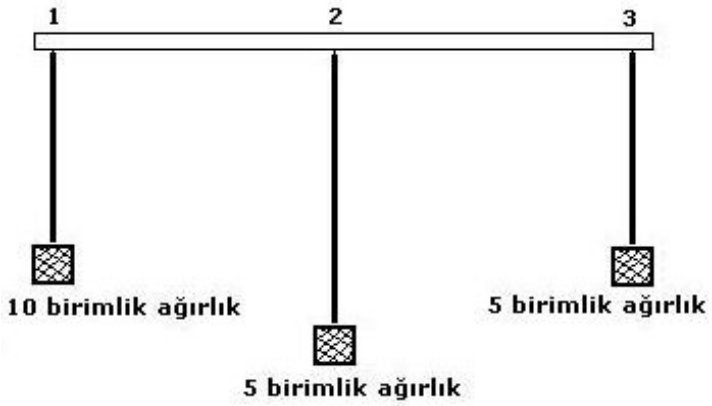
a. 1. ve 2. ipleri
b. 1. ve 3. ipleri
c. 2. ve 3. ipleri
d. 1., 2. ve 3. ipleri
e. Sadece 2. ipi.

Sebep:

1. İplerin uzunlukları eşit olmalıdır. İplerin ağırlıkları farklı olmalıdır.
2. Farklı uzunluklar farklı ağırlıklarla denenmelidir.
3. Bütün ipler ve ağırlıklar diğerleri ile karşılaştırılarak denenmelidir.
4. Sadece en uzun ip denenmelidir. Deney ağırlıkla değil ipin uzunluğu ile ilgilidir.
5. İpin uzunluğu dışında herşeyin aynı olması halinde fark yaratıp yaratmadığı söylenebilir.

Madde: 12

Sarkaç ağırlığı



Yaşar şimdi de ipin ucundaki ağırlığın, ipin ileri ve geri sallanma süresine bir etkisi olup olmadığını öğrenmek istemektedir.

Bu deney için hangi ipi ve ağırlığı kullanmalıdır ?

a. 1. ve 2. ipler
b. 1. ve 3. ipler
c. 2. ve 3. ipler
d. 1., 2., ve 3. ipler
e. Yalnız 1. ip

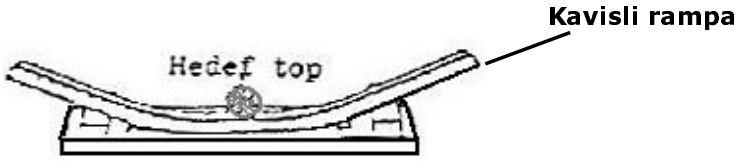
Sebep:

1. Sadece en ağır olan ağırlık denenmelidir. Bu deney uzunlukla değil ağırlıkla ilgilidir.
2. Farklı uzunluklar farklı ağırlıklarla denenmelidir.
3. Bütün ipler ve ağırlıklar diğerleri ile karşılaştırılarak denenmelidir.
4. Ağırlık dışında herşeyin aynı olması halinde ağırlığın fark yaratıp yaratmadığı söylenebilir.
5. İplerin uzunlukları farklı olmalıdır. Ağırlıklar eşit olmalıdır.

Madde: 13

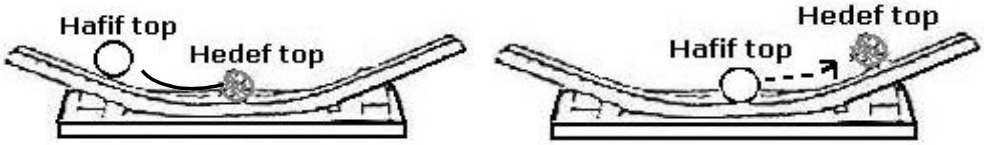
Top # 1

Erhan'ın kavisli bir rampası vardır. Bu rampanın ortasında da hedef top adı verilen bir top vardır.



Biri ağır, diğeri hafif olmak üzere iki top daha vardır. Erhan bu toplardan birini kavisli rampadan yuvarlayıp hedef topu vurabilir, bu da hedef topu rampanın karşı kıyısına iter. Toplar, biri alçak diğeri yüksek olmak üzere iki noktadan yuvarlanabilirler.

Erhan hafif topu alçak noktadan yuvarlar. Top rampadan aşağı yuvarlanır ve hedef topa vurarak onu karşı tarafa iter.



Erhan topun bırakıldığı noktanın hedef topun ilerleme mesafesi üzerinde bir etkisi olup olmadığını bulmak istemektedir.

Bu durumu test etmek için erhan şimdi yüksek noktadan hangi topu yuvarlamalıdır ?

a. Ağır topu b. Hafif topu

Sebep:

1. Hafif topla başladığına göre hafif topla bitirmelidir.
2. İlk defa hafif topu kullandığına göre ikinci defa ağır topu kullanmalıdır.
3. Ağır topun hedef topu daha uzağa götürecek kuvveti vardır.
4. Doğru karşılaştırma yapabilmek için hafif topun yüksek noktadan yuvarlanması gerekir.
5. Topun ağırlığı dikkate alınmadığına göre aynı top kullanılabilir.

Madde: 14

Top #2

Şekil 1'de kavisli bir rampa görülmektedir. Rampanın ortasında ağır hedef top bulunmaktadır. A metalinden yapılmış bir topun rampanın yüksek noktasına konulduğunu ve rampadan aşağı yuvarlandığını düşünelim. Top aşağı yuvarlandığında ağır hedef topu rampanın karşı tarafına hareket ettirecektir.

Şekil 1

Şekil 2'de aynı kavisli rampa görülmektedir. Bu defa rampanın dibine hafif hedef top yerleştirilmiştir. B metalinden yapılmış top A metalinden yapılmış topun yuvarlandığı noktadan yuvarlanır ve hafif hedef topa vurarak rampanın karşı tarafına hareket ettirir.

Şekil 2

Bu deney gerçekten yapıldığında B metalinden yapılmış top hedefi A metalinden yapılmış toptan daha ileri hareket ettirmiştir.

Bu deney B metalinin hedefi A metalinden daha ileri hareket ettirebileceğini ispat etmekte midir ?

a. Evet b. Hayır c. Daha fazla bilgiye ihtiyaç var.

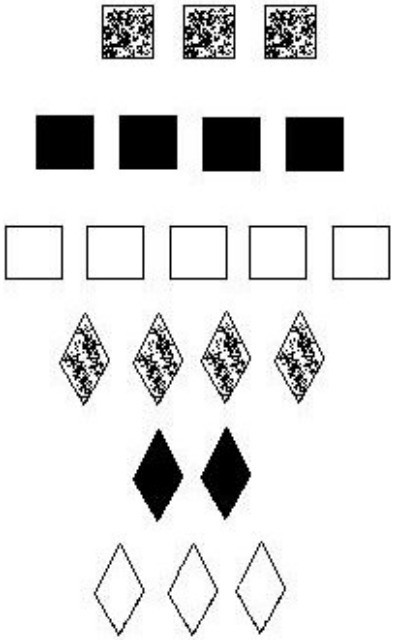
Sebep:

1. Deneyin açıklanmasında B metalinin hedefi A metalinden daha ileri hareket ettirdiği belirtilmiştir.
2. Hedef top hafifledikçe metal top tarafından daha ileri itilecektir.
3. Metal toplar farklı ağırlıklardaki hedef toplara vurmaktadırlar; İki metal hakkında birşey söylemek nümkün değildir.
4. Metal topun ağırlığı arttıkça hedef top daha ileriye gider.
5. A ve B metal topları aynı noktadan bırakılmıştır.

Madde: 15

Kareler ve eşkenar dörtgenler # 1

Bir torbanın içinde,



3 puanlı tahta kare

4 siyah tahta kare

5 beyaz tahta kare

4 puanlı tahta eşkenar dörtgen

2 siyah tahta eşkenar dörtgen

3 beyaz tahta eşkenar dörtgen

vardır.

Bütün kare parçalar aynı büyüklük ve şekildedir. Bütün eşkenar dörtgen parçalar da aynı büyüklük ve şekildedir. Torbadan bir parça çekilir.

Bu parçanın puanlı olma olasılığı nedir ?

a. 3'de 1
b. 4'te 1
c. 7'de 1
d. 21'de 1
e. Başka

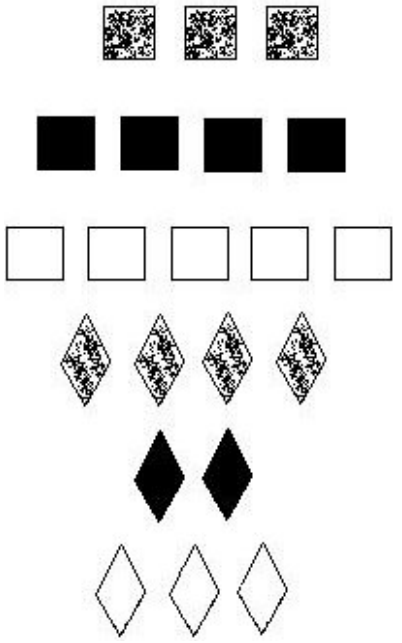
Sebep:

1. Torbanın içinde 21 parça vardır. Bunların içinden 1 puanlı parça seçilebilir.
2. Toplam 7 puanlı parçadan biri seçilebilir.
3. 21 parçanın 7'si puanlıdır.
4. Torbanın içinde üç küme vardır. Bunlardan biri puanlıdır.
5. Kare parçaların 1/4 ü ve eşkenar dörtgen parçaların 4/9 u puanlıdır.

Madde: 16

Kareler ve eşkenar dörtgenler # 2

Bir torbanın içinde



3 puanlı tahta kare

4 siyah tahta kare

5 beyaz tahta kare

4 puanlı tahta eşkenar dörtgen

2 siyah tahta eşkenar dörtgen

3 beyaz tahta eşkenar dörtgen

vardır.

Bütün kare parçalar aynı büyüklük ve şekildedir. Bütün eşkenar dörtgen parçalar da aynı büyüklük ve şekildedir. Torbaya elinizi uzatın ve ilk dokunduğunuz parçayı alın.

Puanlı eşkenar dörtgen veya beyaz eşkenar dörtgen bir parça seçme olasılığı nedir ?

a. 3'de 1
b. 9'da 1
c. 21'de 1
d. 21'de 9
e. Başka

Sebep:

1. Yirmibir parçanın yedisi puanlı veya beyaz eşkenar dörtgendir
2. Puanlıların 4/7'si ve beyazların 3/8 i eşkenar dörtgendir.
3. Yirmibir parçanın dokuzu eşkenar dörtgendir.
4. Torbanın içindeki yirmibir parçadan bir eşkenar dörtgen seçilmesi gerekir.
5. Torbanın içinde dokuz eşkenar dörtgen parça vardır. Bunlardar birinin seçilmesi gerekir.

Madde: 17

Fareler

Bir çiftçi tarlasında yaşayan fareleri gözlemiş ve farelerin zayıf vey şişman olduklarını görmüştür. Aynı zamanda farelerin siyah veya beyaz kuyrukları vardır.

Bu durum çiftçiyi farenin büyüklüğü ile kuyruğunun rengi arasında bir ilişki olup olmadığı konusunda düşündürmüştür. Çiftçi tarlasının bir bölümündeki tüm fareleri yakalamaya ve incelemeye karar vermiştir. Çiftçinin yakaladığı fareler aşağıda görülmektedir.

Farenin büyüklüğü ile kuyruğunun rengi arasında bir ilişki olduğunu düşünür müsünüz (başka bir deyişle belli büyüklükteki bir farenin belli renkte kuyruğu mu vardır) ?

a. Evet

b. Hayır

Sebep:

1. Şişman farelerin 8/11 inin siyah kuyrukları ve zayıf farelerin 3/4'ünün beyaz kuyrukları vardır.
2. Şişman ve zayıf farelerin siyah veya beyaz kuyrukları olabilir.
3. Bütün şişman farelerin siyah kuyrukları yoktur. Bütün zayıf farelerin beyaz kuyrukları yoktur.
4. 18 farenin siyah kuyruğu ve 12'sinin beyaz kuyruğu vardır.
5. 22 fare şişman ve 8 fare zayıftır.

Madde: 18

Balık

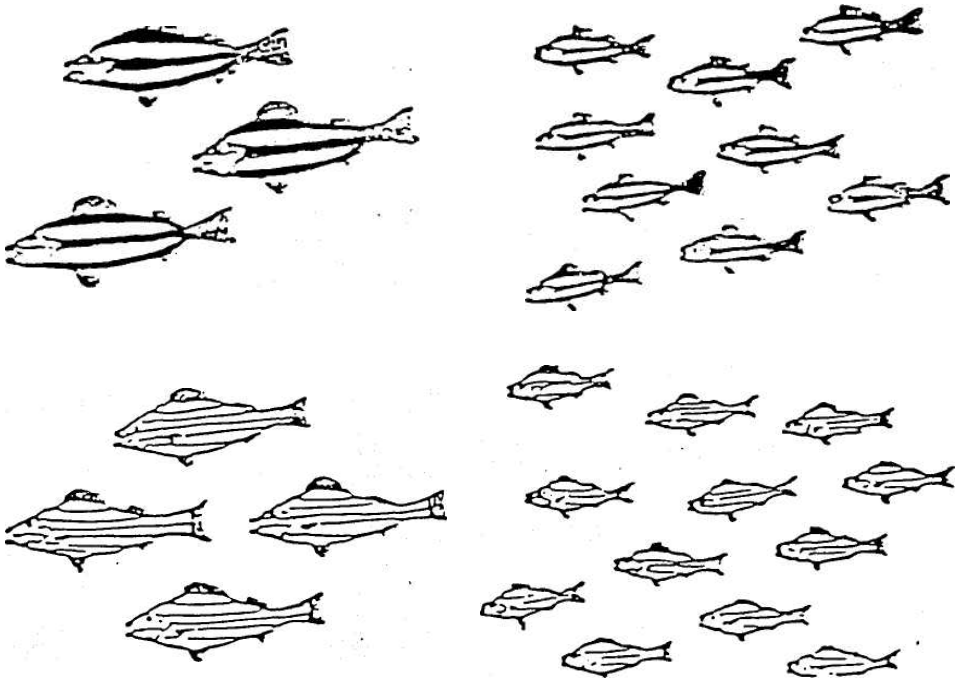
Aşağıdaki balıkların bazıları büyük bazıları küçüktür. Aynı zamanda bazı balıkların geniş, bazılarının ise dar çizgileri vardır.

Balıkların büyüklüğü ile çizgilerinin çeşidi arasında bir ilişki var mıdır (diğer bir deyişle,belli büyüklükteki balığın belli tipte çizgisi mi vardır)?

a. Evet
b. Hayır

Sebep:

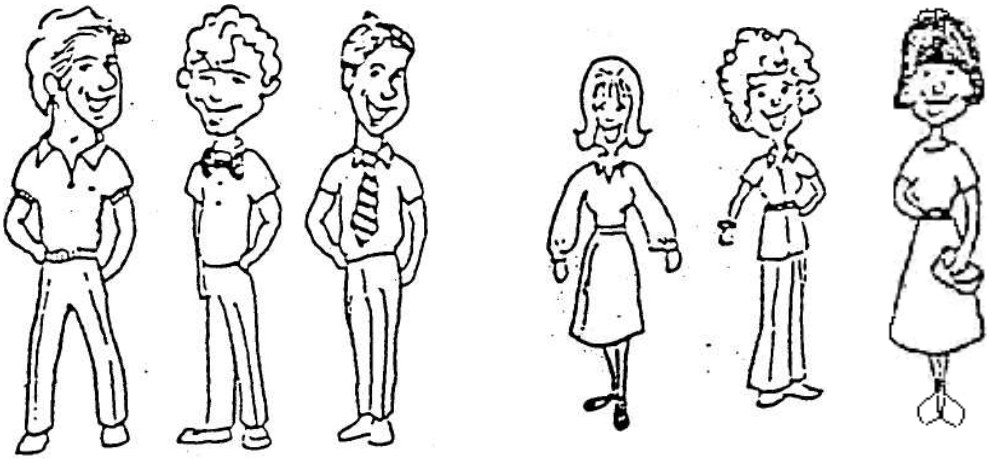
1. Büyük veya küçük balıkların geniş veya dar çizgileri olabilir.
2. Büyük balıkların 3/7'sinin ve küçük balıkların 9/21'inin geniş çizgileri vardır.
3. 7 balık büyük ve 21 balık küçüktür.
4. Bütün büyük balıkların geniş çizgileri ve bütüft. küçük balıklar dar çizgileri yoktur.
5. Balıkların 12/28'inin geniş çizgileri ve 16/28'inin dar çizgileri vardır.



Madde : 19

Dans

Akşam yemeğinden sonra bazı öğrenciler dansa gitmeye karar verirler, Üç erkek: AHMET (A), BORA (B) ve CAHİT (C) ve üç kız: LEYLA (L), MİNE (M), ve NESRİN (N) öğrenci vardır.



AHMET	BORA	CAHİT	LEYLA	MİNE	NESRİN
(A)	(B)	(C)	(L)	(M)	(N)

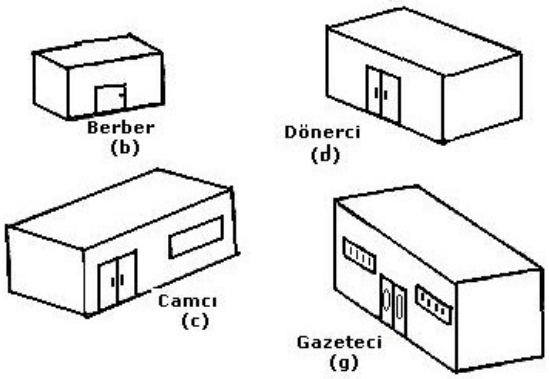
AHMET ve LEYLA, yani A-L olası dans çiftlerinden biridir.

Bütün diğer olası dans çiftlerini sıralayın. Erkekler erkeklerle ve kızlar kızlarla dans edemezler.

Madde: 20

Alışveriş Merkezi

Yeni bir Alışveriş merkezinde zemin kata 4 dükkan yerleştirilecektir. Bunlar Berber (B), Dönerci (D), Gazeteci (G), ve Camcı (C)'dır.



Dört dükkanın olası yerleştirilme şekillerinden biri BDGC'dir.

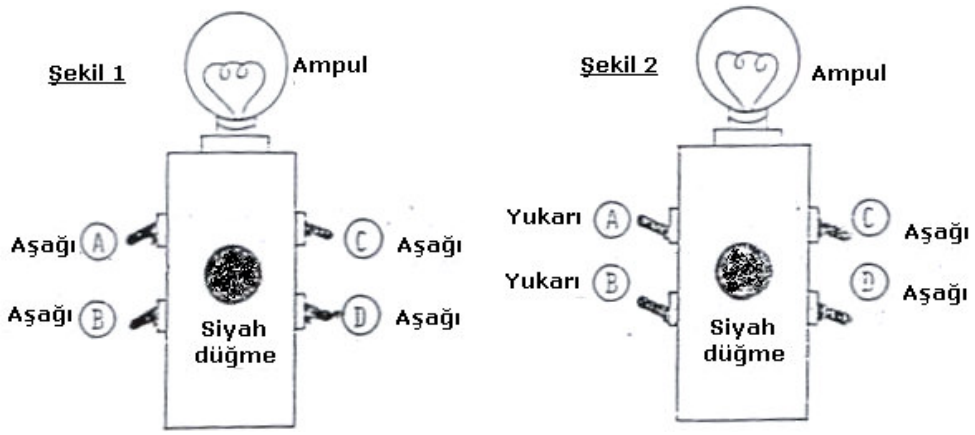
Bu da, BERBER'in ilk, DÖNERCİ'nin onun yanında, daha sonra GAZETECİ ve sona da CAMCI'nın yerleşmesi demektir.

Bu dört yere dükkanların tüm diğer olası yerleştirilme şekillerini sıralayınız.

Madde: 21

Işık kutusu

Taner'in şekil I′deki gibi bir feneri vardır.



Bu özel fenerin dört düğmesi vardır; düğmeler A, B, C ve D harfleri ile gösterilmiştir. Fenerin yanması için doğru düğme veya düğmelerin aşağı yukarı hareket ettirilmesi gerekmektedir. Taner farklı denemelerde değişik düğmeleri YUKARI pozisyonuna getirir ve siyah düğmeye basarak ışığın yanıp yanmadığını kontrol eder. Olası bir kombinasyon A ve B düğmeleri yukarı kaldırmak ve siyah düğmeye basmaktır. Şekil 2'deki gibi, AB yukarı CD aşağı.

Taner'in ışığı yakabilmesi için mümkün olan tüm düğme konumları kombinasyonlarını yazınız.